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SPRING MEETING PAPERS

IN A RECENT ADDRESS, Past-President Hollis, who will be one of the Society's hosts at the coming Spring Meeting, expressed the relation of the engineer to the war in the following words: "We all know that this war is a problem in manufacture, business and organization. Much of it is engineering, but it is not an engineer's war, a farmer's war nor a banker's war. It is a people's war in which every individual, man, woman and child, counts for something."

While it is true that the burden falls heavily upon those whose business it is to secure mass production of the mechanical devices required by our men at the front, the first responsibility of the engineer is that of a loyal citizen, ready to answer the call for public service. It is in this spirit that the members of the Society are counseled to meet at Worcester, Mass., June 4 to 7, for conference, mutual help and inspiration. It will be a time for interchange of ideas, planning for the future and a strengthening of one's abilities so that each may return to his strenuous duties better equipped for the months which are to follow. This will be the third war convention of the Society, with a remarkable program carefully developed in all its details, and having a direct bearing on the stupendous undertakings in which the members of the Society are engaged.

Readers of THE JOURNAL are referred to page 404 of this issue for the program of the meeting, and other information of interest to those expecting to attend.

PAPERS FOR GENERAL SESSIONS

THE SPRING MEETING PROGRAM comprises a number of addresses, papers and discussions relating to the procurement and manufacture of supplies for the Government, ways and means for effecting fuel economy, and the problem of instructing and housing labor under war conditions; besides the usual number of general technical papers necessary to maintain the TRANSACTIONS of the Society. These general papers are published in abstract form in this number of THE JOURNAL, discussion upon which is solicited. Other papers contributed by the New England Sections and the Providence Engineering Society will appear in the next number. Except in a few instances, the matter relating to the war will be in the form of addresses or topical discussions, and will be published after the meeting. Pamphlet copies of the complete papers will be ready for distribution to all who desire them in advance of the meeting.

EFFECT OF MOISTURE REABSORPTION ON COMPRESSIVE STRENGTH OF AIR-DRIED TIMBER

By IRVING H. COWDREY,[1] CAMBRIDGE, MASS.

Non-Member

THE effect of moisture on the properties of timber has become a well-established and recognized fact. Every practical man, whether he be an engineer or a craftsman, knows full well that the removal of moisture from timber, or the so-called "seasoning," produces marked changes in its strength, hardness, stiffness, resiliency and other characteristic properties. Much has been done in the way of scientific investigation by the Bureau of Forestry, The Forest Products Laboratory and various universities and technical schools to determine the effect of the progressive removal of moisture on the strength of timber of all kinds, and the results obtained have been published.

To the reversal of this process there has been given considerably less attention. There is often expressed great surprise at the rapid and very appreciable regain of moisture by wood after it is removed from the dry kiln. This reabsorption, moreover, is not confined to kiln-dried wood, but occurs as well in the case of timber which has been thoroughly air-dried. In fact, the reabsorptive power of air-dried timber is believed to be somewhat greater than is that of timber which has been properly and thoroughly kiln-dried. The effect of atmospheric conditions on the physical properties of timber through their effect on the moisture content of the wood is well exemplified by the behavior of certain beams which were subjected to a time test under load for several years in the laboratories of the Massachusetts Institute of Technology. During the summer months these beams always manifested a very noticeable stiffening and consequent decrease in deflection at the center, even though subjected to load far in excess of the proper working load for such beams. While, of course, no moisture determinations were possible under the conditions noted above, yet the common fund of engineering knowledge would point to the moisture factor as the proper explanation of this observed behavior.

PROBLEMS TO BE SOLVED

If, then, wood responds so quickly in its reabsorption of moisture under very ordinary atmospheric conditions, and in consequence thereof undergoes change of properties, how much greater will be the response and the consequent change of properties if the timber be introduced into a saturated atmosphere at reasonably high temperatures, or if it be completely submerged in water? For example, if the roof of a laundry or of the dye house or finishing room in certain textile industries be of a timber-truss or beam construction, what is the effect on such timbers of the temperature of, say, 120 deg. fahr. with saturation? Again, suppose the basement of a heavily loaded warehouse be flooded. If the supporting col-

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For presentation at the Spring Meeting, Worcester, Mass., June 4 to 7, 1918, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form and advance copies of the paper may be obtained by members gratis upon application. All papers are subject to revision.

umns be of timber, to what extent will their ability to reabsorb moisture affect the stability of the structure?

A recognition of the importance of these items and the belief that reabsorption is a factor to be reckoned with has led to the conducting of a series of investigations during the past year in the Testing Materials Laboratory of the Massachusetts Institute of Technology to determine the quantitative effect, if possible, of such conditions.

During the past few years the eastern lumber markets, as typified by Boston, have witnessed the entrance of Douglas fir (*Pseudotsuga Douglasii*) as a competitor in the field of structural timber. This fact led the experimenters to make a parallel investigation for purposes of comparing this timber with the better-known southern hard pine, which has been so long established in the structural engineering of New England. In so far as the writer is aware, this is the first work of the kind to have been done on Douglas fir. The pine used

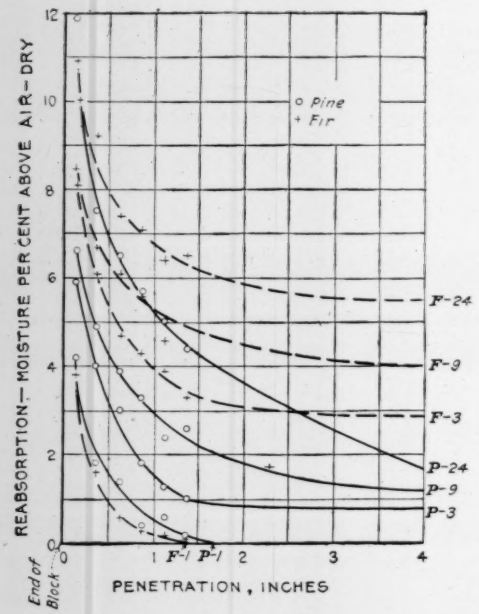

FIG. 1 REABSORPTION OF SPECIMENS WHEN EXPOSED TO SATURATED AIR AT 120 DEG. FAHR.

P-1 indicates pine treated 1 hr.; *F-9*, fir treated 9 hr.; other symbols to be similarly interpreted.

falls under the classification of "dense southern pine" according to the standards of the American Society for Testing Materials, and is very probably the long-leaf yellow pine (*Pinus palustris*).

The tests were carried out, it is true, upon small specimens, and in consequence are open to criticism such as has been made concerning much of the work which has been done by the Bureau of Forestry. It must be acknowledged that the results are scarcely to be used as constants of design, but it is believed that they may well be used as indicative of certain truths and as a means of comparison in the guidance of the users of the two timbers placed under observation.

NATURE OF THE INVESTIGATION

The investigation under discussion may be briefly outlined as follows: The stock used had been purchased in the open market without any special care in selection. In the form of 4-in. planks it remained in the testing laboratories about six months under the conditions of heat and moisture ordinarily pertaining to such localities, being open to free and complete circulation of air over and around the material.

Tests showed the moisture content to be between 6 and 8 per cent for all pieces. The timber, then, may be considered to have been thoroughly air-dried. From these planks were cut specimens which were planed to a section 2 in. by 2 in. and 20 in. long. These pieces were cut further into blocks 8 in. long, and the pairs thus obtained were used in most cases under similar conditions of treatment for check purposes. All treatments were conducted on specimens 8 in. long and tests were made on specimens 6 in. long formed by the removal of 1 in. from each end of the treated specimen.

A number of specimens of both pine and fir were tested in the air-dry condition to establish their initial properties. One set consisting of 20 pieces of pine and 20 pieces of fir was subjected for various lengths of time to a saturated atmosphere at 120 deg. fahr. Another similar set was immersed in fresh water at 70 deg. fahr. for various periods of time.

While the moisture even in so thin a block as those investigated will doubtless vary from surface to surface, yet it seems sufficiently accurate for the purposes of this paper to take the average value as representative of the conditions at the center of the section. These values have been so assumed and are plotted in the curves of Figs. 1 and 2.

The water present in wood may exist (*a*) as free water within the cellular spaces, the canals and ducts, and possibly to some slight extent in the intercellular cavities; and (*b*) as water which has been actually absorbed by the material which constitutes the cell walls.

It is commonly supposed that the absorption of water from moist air at least is first an absorption by the cell walls, and that later under some conditions there occurs a partial filling of the cell cavities. The maximum water content possible without the presence of free water in the cells and canals is known as the "fiber-saturation point." When water is absorbed because of the actual immersion of the wood it is very likely that free water may exist in the cells without the cell walls having absorbed a quantity sufficient to produce fiber saturation. For most of the commoner timbers this fiber-saturation point occurs at a moisture content of approximately 25 per cent.

Most writers consider that it is only this second form, or "imbibed" water, as it is sometimes called, which affects the strength. No satisfactory theories have been advanced to elucidate the phenomenon. It would seem to the writer as though perhaps there may occur some of the effects of colloidal solution, which may to some extent be borne out by the fact that a very complete kiln-drying at high temperature prevents or markedly decreases certain effects commonly produced by reabsorption of moisture such as swelling, increase of pliability, etc.

Again, the writer would hold that the free water in the cells and canals may also have a weakening effect, due to re-solution of some of the salts which are undoubtedly deposited within the cells as the sap dries out, or in the case of heart wood by infiltration during the life of the tree. These crystalline deposits, it would seem, must have a stiffening effect, and, if present in sufficient quantity to fill completely the cell or to bridge it at any point, should add quite materially to the rigidity of the cell, as latticing adds to the rigidity of structural compression members.

RELATIVE RATES OF MOISTURE PENETRATION LONGITUDINALLY

Only the rate of penetration in the direction of the fiber was investigated. The specimens, in the form of blocks 2 in. by 2

in. by 8 in. were subjected to the desired treatment for periods ranging from one hour to 117 hours. At the end of the period of treatment the moisture content was obtained as previously described.

Reabsorption When Exposed to Saturated Air at 120 Deg. Fahr. The specimens were treated by placing them on a grid just above the surface of hot water in a covered steamer freely vented to the air. The temperature of the vapor in the steamer was maintained within the limits of 2 deg. fahr. variation during the longest period of treatment, namely 24 hours.

Fig. 1 shows the reabsorption of the specimens during periods of 1, 3, 9 and 24 hours of treatment. It has seemed best to plot the reabsorption in terms of the moisture content in excess of that present in the air-dried condition rather than the absolute moisture content. This was done to eliminate if possible any variation of hygroscopic action inherent in the specimen due to structural peculiarities.

Referring to curves *P*-1 and *F*-1 representing the conditions at the end of an hour's treatment, it will be noticed that no reabsorption was manifest beyond a point approximately 1½ in. from the end. The curves *F*-3 and *P*-3, showing the effect of 3 hours' treatment, clearly indicate some absorption, even at a distance of 4 in. from the exposed end grain. This furnishes a very striking example of the extreme rapidity with which moisture will penetrate along the grain of timber when it is exposed to the action of hot, moist air.

It should be noted that in none of the treatments did the reabsorption become greater than 12 per cent average moisture in the first ¼ in. from the end. With the air-dry condition of 8 per cent of moisture or less, giving total moisture 20 per cent or less, it would seem that the fiber-saturation point was not attained. However, the point plotted represents the average only for the first ¼ in., and as the plots show, the moisture content decreases very rapidly at first; hence it seems fair to presume that the walls of the cells immediately adjacent to the surface may have reached the point of saturation. From this it might be inferred that saturated air at 120 deg. fahr. is capable of producing fiber saturation. It seems also reasonable to suppose that if the treatment were continued for a period of sufficient length this condition might extend throughout the timber regardless of size. The logical conclusion to be drawn from this leads to the statement that *timbers subjected to the action of saturated air at 120 deg. fahr. must be designed on a basis of constants determined from tests on green timber.*

Reabsorption When Completely Immersed in Fresh Water at 70 Deg. Fahr. Reabsorption tests were made at the end of 1, 24, 48, 72 and 117 hours. The observations were all concordant, and hence only the data obtained from the 24-, 48- and 117-hour periods have been plotted in Fig. 2. Here the relative reabsorptive powers of pine and fir are much more nearly alike than in the case of the treatment in saturated air. Yet even here it will be noted that in all cases the reabsorptive power of the fir is slightly greater than that of the pine.

While the time required for fiber saturation is not definite in the case of timber immersed in water, yet an inspection of the curves of Fig. 2 shows clearly that such saturation undoubtedly occurs, and that it is only a matter of time, whether in the case of columns or beams of timber, even though previously air-dried, for them to be reduced to the character of green wood. It would seem, then, that conclusions relative to the design of timber liable to submersion are similar to those drawn at the close of the discussion of the effect of treatment by saturated air.

Comparison of Figs. 2 and 3 beyond the first half inch from the exposed end shows that the rapidity of reabsorption is much less when the wood is immersed in water at 70 deg. fahr. than when exposed to air saturated at 120 deg. fahr. In detail it will be noted that 24 hours in water are required to produce approximately the same reabsorption as 3 hours' treatment in moist air, and that the reabsorption after 48 hours' submersion is approximately that attained during a 24-hour exposure to moist air.

Effect of Reabsorption on the Compressive Strength

As previously noted, the blocks under investigation were 2 in. by 2 in. by 8 in. After treatment a section 1 in. thick was removed from each end, thus giving a specimen 6 in. long for the compression tests. The ends were squared in a metal

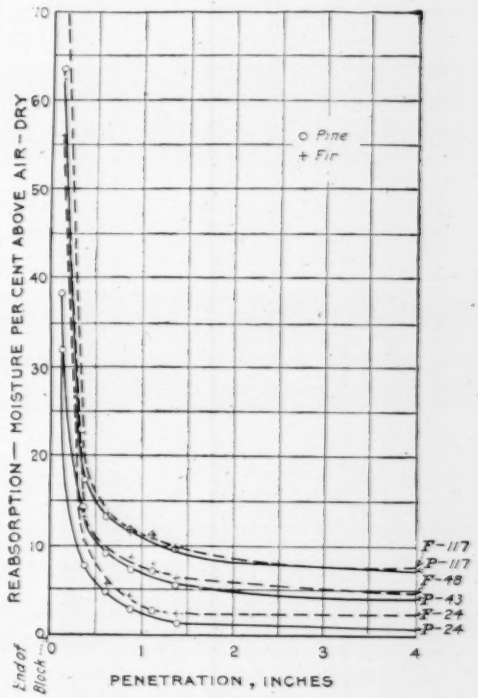

FIG. 2 REABSORPTION OF SPECIMENS WHEN COMPLETELY IMMERSED IN FRESH WATER AT 70 DEG. FAHR.

P-2½ indicates pine treated 24 hr.; *F*-48, fir treated 48 hr.; other symbols to be similarly interpreted.

miter box so that the faces subjected to pressure were as nearly parallel as possible. The tests were conducted on a 100,000-lb.-capacity Olsen testing machine having a ball-and-socket joint on the moving head. This should completely obviate the introduction of any eccentricity of loading, and the failure of the specimens would indicate a pure compression stress.

After failure a quarter-inch section was removed from the specimen at the point of fracture, and from this the moisture content was obtained as previously described.

Figs. 3 and 4 have been prepared to show the relations, if any exist, between the actual moisture content and the crushing strength of the two woods under discussion.

All of the fir tested, with two exceptions, showed from 12 to 17 rings per inch measured radially; the summer wood comprised from 30 to 60 per cent of the total growth; the air-dry density ranged between 31 and 36 lb. per cu. ft.

The pine under investigation showed from 7 to 10 rings per inch measured radially. The summer wood ranged from 30 to

50 per cent of the total growth. The air-dry density was between 32 and 36 lb. per cu. ft.

Pine specimens *S* (three in number, see Fig. 4) had but 6 rings per inch, showing only 25 per cent summer wood, and an air-dry density of about 30 lb. per cu. ft. It is evident that the wood from which these were cut should be classed as "sound" rather than as "dense" southern pine according to the A. S. T. M. standards.

The moisture-strength relations for the fir and pine will now be taken up separately and later compared.

Douglas Fir. The most superficial glance at Fig. 3 will very clearly show that the compressive strength of the wood falls

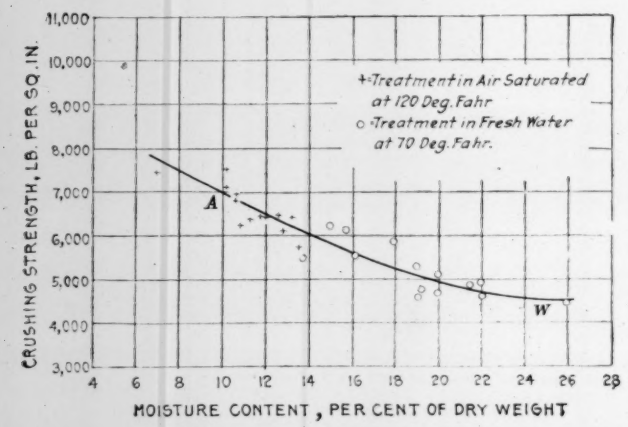

FIG. 3 RELATION BETWEEN MOISTURE CONTENT AND CRUSHING STRENGTH OF DOUGLAS FIR

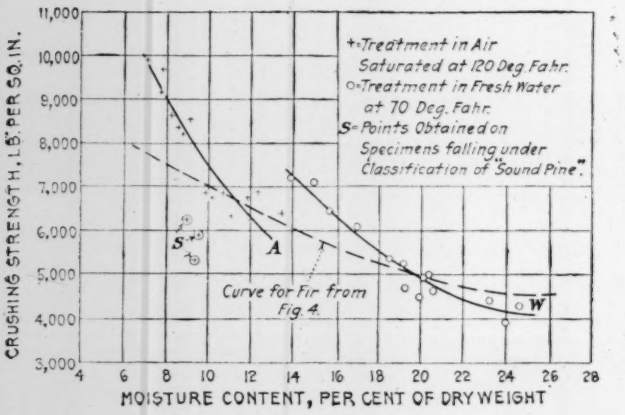

FIG. 4 RELATION BETWEEN MOISTURE CONTENT AND CRUSHING STRENGTH OF YELLOW PINE

as the moisture content increases. The material is of organic origin and subject consequently to manifold variation. Hence it is only to be expected that the plotted points shall assume a more or less "gun-shot" arrangement. In such a case the choice of the best representative curve is open to all the elements of variation arising in the personal equation of the investigator. The curve drawn, however, is assumed by the writer to be fairly representative and is at least indicative of certain fundamental relations.

The data were obtained as previously explained from tests made on specimens subjected to radically different treatments. In the case of the fir, nevertheless, the resulting graph is evidently a continuous line. The inclination is somewhat sharper with the lower moisture contents and flattens out, becoming approximately horizontal at a moisture content of about 25 per cent. This corresponds very closely with the fiber-saturation point previously referred to and would seem to bear out the existing theory that only the "imbibed" moisture affects the strength in compression.

While it must be kept in mind that the values of the strengths here recorded are in no way indicative of the proper constants for use in design, yet it is felt that certain of the relations apparent are of fundamental truth. It will be noted that the treatment of wood by exposure to air saturated at a temperature of 120 deg. fahr. results in a compressive strength of about 25 per cent less than the strength of air-dry timber. This reduction appears at about 14 per cent moisture content.

Submersion in water at 70 deg. fahr. for a period of 117 hours produces at the point of fracture a moisture content of 26 per cent, thereby reducing the strength to a value about 40 per cent below that of air-dry wood of the same quality.

Yellow Pine. The data recorded in Fig. 4 offer certain marked variations from those shown for fir in Fig. 3, the curve for which has been transposed to this plot as a dash line. It is very obvious that the data obtained from the pine yield plotted points which cannot be satisfactorily represented by a single line. The data from the water-soaked specimen, marked *W*, yield a fairly determinate curve. The data from the specimens exposed to the moist air, marked *A*, might be reasonably well represented by a variety of lines. However, it seems fair to presume that the two lines will be of the same general type, even though they are discontinuous. Such has been the assumption used as a guide in drawing the representative lines.

The generalizations for the pine are quite similar to those drawn from the graph characteristic of the effect of reabsorption by the fir. The decrease in strength is at first quite rapid with the increase of moisture content. It later flattens, becoming nearly horizontal at about 25 per cent moisture content, again indicating this value as the fiber-saturation point.

The rate of decrease in strength seems to be more rapid for yellow pine than for fir. In the case of the specimens investigated this decrease becomes about 35 per cent after 24 hours' exposure to air saturated at 120 deg. fahr. It is only fair to suggest that this decrease may not be due entirely to moisture, which point is discussed in a later paragraph.

Due to the extremely rapid reabsorption, no points were obtained for the soaked specimens between the air-dry condition and about 14 per cent of moisture. The graph *W* as drawn, however, if extrapolated as a straight line will pass very close to the data obtained from the air-dry material. This graph shows that the moisture content of about 25 per cent which was present 1 in. from the exposed end after a soaking of 117 hours, resulted in a strength nearly 60 per cent below the strength of the air-dry material.

Reasons for the Discontinuity of the Graph. The wood treated to the moist air at 120 deg. fahr. was tested immediately upon removal from the steamer. It was warm when subjected to pressure; in some cases the temperature of the inner portions was probably at least 100 deg. fahr. Pine is a very resinous wood. At the temperatures maintained this resinous material will soften, and some of the normally solid constituents will undoubtedly become actually liquefied. The portions normally in the state of a liquid of high viscosity will undoubtedly have their viscosity considerably lowered. The effect of this action will be that of a general removal of the stiffening action of the cell contents and a possible lubricating effect tending to permit a greater freedom of movement between cells which are poorly adherent because of incidents of growth. This effect is additive to the general effect of the absorption of moisture and may well explain the sharp pitch of the curve *A*.

The temperature of the water (70 deg. fahr.) used for the soaking treatment is probably insufficient to produce the above-noted effect. In fact, the temperature is approximately that at which the air-dry specimens were tested. It would seem, then, that the temperature factor may reasonably be eliminated from a discussion of the curve *W*. If such be the case, it is to be expected that a given moisture content when obtained in the water at 70 deg. fahr. will show a less marked weakening effect than does the same moisture content when resulting from exposure to moist air at 120 deg. fahr. Observing the conditions at a moisture of 14 per cent, such is found to be the case. The difference between the ordinates of curves *A* and *W* at this degree of saturation may well be taken to represent the weakening effect of heat due to softening of the resinous compounds by a heating for 24 hours at 120 deg. fahr.

Since the quantity of resinous matter in the Douglas fir is much less than that in the pine, this temperature effect would doubtless be absent and the resulting graph be a continuous curve, as was found to be the case.

The specimens giving the points marked *S* are of considerable interest as an exemplification of the fact that wood of coarse growth, low percentage of summer wood, and corresponding lesser density yields a lower compressive strength than when the reverse conditions obtain. Though the number of pieces coming in this category is small, yet the facts point strongly toward a justification of the acceptance of the so-called "density rule" of the standards of the American Society for Testing Materials.

Comparisons and General Conclusions

In the interpretation and subsequent use of the data furnished in this paper, it must be kept in mind that the specimens tested were brought in the open market of Boston; that no special selection of material was made except so far as was necessary to obtain specimens of reasonably straight grain, free from knots and serious defects; that tests were made on small specimens, limited in number and selected from a very small initial quantity of lumber; that in consequence of the above facts the results must be considered comparative and qualitative rather than definitely quantitative.

With all the above in mind, an analysis of the preceding data as shown by the accompanying plots seems to justify the following statements:

In the air-dry condition with approximately equal moisture contents the compressive strength of hard pine is about 25 per cent greater than that of Douglas fir.

When exposed to air saturated with water vapor at 120 deg. fahr. and when immersed in fresh water at 70 deg. fahr., the moisture reabsorption of air-dried wood is greater and more rapid in the case of fir than in the case of pine.

The temperature effect on strength decrease is of more importance on pine than on fir.

Pine shows a more rapid decrease in strength with the moisture increase than does fir. [The more rapid reabsorption by fir tends to offset this effect when the time element is used as a basis, so that for a given time of treatment the pine remains the stronger, although the strengths tend to approach each other with more extended treatment.]

For moisture contents above 11 per cent when due to reabsorption from air saturated at 120 deg. fahr., the fir is stronger in compression than is the pine. The same relation appears for moisture contents greater than 20 per cent when due to soaking in fresh water at 70 deg. fahr.

EFFICIENCY OF GEAR DRIVES

An Accurate Method of Testing

By C. M. ALLEN, WORCESTER, MASS.
Member of the Society
and
F. W. ROYS, WORCESTER, MASS.
Non-Member

APPARATUS for determining the efficiency of gears and other drives has recently been developed and used for making tests in the Mechanical Engineering Laboratories of the Worcester Polytechnic Institute. The fundamental principle of the apparatus consists in the direct measurement of the loss of power in the gear drive instead of the usual method of determining the input and output and subtracting one from the other.

Since the efficiency of good geared drives is relatively high, the input and output are very nearly equal, and any small errors in the measurement of these relatively large quantities will make a very large per cent error in the difference, which is the power loss.

It is therefore evident that a method by which the loss may be measured directly and independently of the input and output would be very much more accurate.

Theory of Apparatus Used in the Tests

The theory of the apparatus which was used in the tests is as follows: An electric motor is so hung in a cradle that both its armature and field are free to turn. The armature shaft is connected directly to the pinion gear shaft and the driven shaft directly to an Alden absorption dynamometer. The reaction of the motor field is balanced by the action of the absorption dynamometer through a simple lever. The arms of the lever are accurately proportioned to the ratio of the gears.

The general idea of the apparatus is as follows: An electric induction motor is hung in a cradle on double roller bearings, and an arm attached to the motor casing makes a cradle dynamometer. The motor shaft is connected directly to the drive shaft and an Alden dynamometer is put on the driven shaft. These dynamometers are so arranged that the force exerted by the end of the arms is downward. The arms of the dynamometers are of equal length and at the end of each is a fixed knife edge. A lever with three knife edges mounted upon it has the two outer knife edges adjusted so that the distance between them is equal to the distance (horizontal) between the dynamometer knife edges. The third knife edge divides this distance into segments whose ratio to each other is the same as the gear ratio. These three knife edges lie in the same straight line. The lever is now placed directly over the line between the dynamometer knife edges, and is supported by the third knife edge which rests on platform scales. The end knife edges of the lever are connected to the dynamometers in such a way that the high-speed dynamometer is connected to the long arm of the lever. A counterweight and a rider weight are mounted upon the lever. See Fig. 1.

Method of Testing

The method of testing, so far as the operation of the lever

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system is concerned, is identical for all tests, and therefore the explanation of its action is made perfectly general.

The center of gravity of the Alden brake was very nearly in the horizontal plane, so that a slight movement of the arm did not measurably affect its balance. The cradle dynamometer was so loaded that its center of gravity was only a short distance below the shaft center, and a load of 2 lb. at the end of the arm was enough to entirely upset its equilibrium. The lever was then placed in position as described above and statically balanced by means of the counterweight shown in Fig. 1. A long pointer attached to the lever showed the position of the system relatively to the initial condition of balance.

When the rider weight W was in its initial position, the load of moment, and when corrected for the speed of the apparatus it is a measurement of the power loss.

Here the input power is automatically balanced against the output, and any little change in the latter is immediately taken care of by the motor, and it is impossible for the apparatus to be out of balance except by the amount of the transmission loss. This is the feature of the method which distinguishes it from all others.

The power transmitted by the drive may be computed by noting the change in the load P_3 on the platform scales, and such computations will be shown later.

In operating it was found necessary to start the apparatus and let it run for several minutes before taking note of the

TABLE 1 DATA OF EFFICIENCY TEST OF BEVEL-GEAR DRIVE

PRACTICALLY NO LUBRICATION

R.p.m. of motor	Scale pan, lb.	P_3 lb.	0.2122 P_3	x ft.	0.759 x	P_1	Input, hp_{1000}	Input, actual hp.	Rider hp_{1000}	Hp. loss	Output, hp.	Efficiency, per cent
1	2	3	4	5	6	7	8	9	10	11	12	13
1115	5	200	42.44	1.70	1.291	43.731	21.86	24.37	0.746	0.832	23.532	96.6
1112	5	200	42.44	1.70	1.291	43.731	21.86	24.37	0.810	0.903	23.467	96.3
1112	5	200	42.44	1.70	1.291	43.731	21.86	24.37	0.770	0.859	23.511	96.5
1112	5	200	42.44	1.70	1.291	43.731	21.86	24.37	0.820	0.914	23.456	96.3
1119	5	200	42.44	1.70	1.291	43.731	21.86	24.37	0.806	0.899	23.471	96.4
1146	4	160	33.95	1.25	0.949	34.899	17.45	19.92	0.660	0.753	19.167	96.2
1146	4	160	33.95	1.25	0.949	34.899	17.45	19.92	0.615	0.702	19.218	96.5
1141	4	160	33.95	1.25	0.949	34.899	17.45	19.92	0.620	0.708	19.212	96.4
1141	4	160	33.95	1.25	0.949	34.899	17.45	19.92	0.612	0.699	19.224	96.5
1138	4	160	33.95	1.25	0.949	34.899	17.45	19.92	0.610	0.696	19.224	96.5
1160	3	120	25.46	1.00	0.759	26.219	13.11	15.14	0.486	0.561	14.579	96.3
1150	3	120	25.46	1.00	0.759	26.219	13.11	15.14	0.490	0.566	14.574	96.2
1150	3	120	25.46	1.00	0.759	26.219	13.11	15.14	0.486	0.561	14.579	96.3
1150	3	120	25.46	1.00	0.759	26.219	13.11	15.14	0.484	0.559	14.581	96.3
1172	2	80	16.97	0.62	0.471	17.441	8.72	10.25	0.316	0.371	9.889	96.4
1172	2	80	16.97	0.62	0.471	17.441	8.72	10.25	0.310	0.364	9.886	96.4
1177	2	80	16.97	0.62	0.471	17.441	8.72	10.25	0.308	0.367	9.888	96.4
1196	1	40	8.49	0.40	0.337	8.827	4.42	5.26	0.196	0.234	5.026	95.35
1196	1	40	8.49	0.40	0.337	8.827	4.42	5.26	0.204	0.243	5.017	95.35
1190	1	40	8.49	0.40	0.337	8.827	4.42	5.26	0.204	0.243	5.017	95.35
1205	½	20	4.245	0.37	0.281	4.526	2.26	2.72	0.184	0.222	2.498	91.9
1205	½	20	4.245	0.37	0.281	4.526	2.26	2.72	0.184	0.222	2.498	91.9

P_3 (see Fig. 1) was noted as the initial reading of the platform scales.

The variables entering into the balance of this apparatus are then the forces P_1, P_2 and P_3, and the displacement of the rider weight. P_3 may be measured at any time while the apparatus is in operation, and so may the displacement of the rider weight.

It should be noted here that the amount of P_3 has nothing to do with the calculation of the power loss, which is found as follows:

METHOD OF MEASURING POWER LOSS

It will be seen from the preceding description and from Fig. 1 that $P_1x = P_2y$ for 100 per cent efficiency; but since the efficiency is never 100 per cent, P_1x must exceed P_2y by the amount necessary to overcome the loss in moment. This difference immediately upsets the balance of the lever, of course, but equilibrium may again be restored by shifting the position of the rider weight in the proper direction. This displacement of the rider weight is therefore a measurement of the change initial position of the lever. The zero reading was frequently checked during the period of testing.

EFFICIENCY TEST OF BEVEL-GEAR DRIVE

Data of Gears and Apparatus. The gears were 5 per cent nickel steel, case-hardened, 5 pitch, 1½-in. face. They were cut by the Brown & Sharpe Mfg. Co. and were mounted by them on ball bearings especially designed for testing purposes. Fig. 2 shows the apparatus set up for this test. Following are the preliminary data employed:

Number of teeth in gear.....52
Number of teeth in pinion.....14
Ratio, 52 ÷ 14.....3.714
Total length of lever between outside knife edges (see Fig. 3).....3.95 ft.
Length of long arm of lever.....3.112 ft. = 37.344 in.
Length of short arm of lever.....0.838 ft. = 10.056 in.
Length of dynamometer arms.....31.5 in.

A force of 2 lb. at 31.5 in. is equivalent to 1 hp. at 1000 r.p.m., for which the expression 1 hp_{1000} will be used.

Calculation of Horsepower Loss from Movement of Rider. Referring to Fig 3, a force of 2 lb. at $P_1 = 1$ hp_{1000}. Therefore $2 \times 37.344 =$ in-lb. of moment in lever necessary for 1 hp_{1000}, and if the rider weight is 3 lb., then for this to balance 1 hp_{1000}, $3x$ must equal 2×37.344, whence $x = 24.893$, and therefore a movement of 24.893 in. of the rider is equivalent to 1 hp_{1000} for a 3-lb. rider.

If the rider weighs but 1½ lb., then the same displacement means only ½ hp_{1000}. A paper scale was made according to these figures and was fastened to the lever. The readings for hp. loss were taken from it throughout the test.

Calculation for Horsepower Input. Referring to Fig. 3, since the initial load of P_2 was taken with the rider weight W already on the lever, a change in the position of W does not change P_2, but merely changes the moment. Therefore, in moment equations of the lever, regardless of where the center of moments is taken, the arm of the moment of W is always the distance from the zero position.

The force P_1 is a measure of the input power if the speed is known, and it is merely necessary to calculate this value in order to solve the problem. Considering the moment equation of the lever, we have

$$0.838P_2 - 3.95P_1 + Wx = 0$$

whence

$$P_1 = \frac{0.838P_2 + Wx}{3.95}$$

If $W = 3$ lb.,

$$P_1 = 0.2122P_2 + 0.759x$$

if $W = 1.5$ lb.,

$$P_1 = 0.2122P_2 + 0.379x$$

x being the displacement of W measured in feet.

Referring to Table 1, for accuracy of recorded data the values in column 5 (x ft.) and column 10 (rider hp_{1000}) should vary together, since they both refer to the displacement.

Column 10 is recorded for one purpose and read from the paper scale directly in hp_{1000}, while column 5 is recorded for

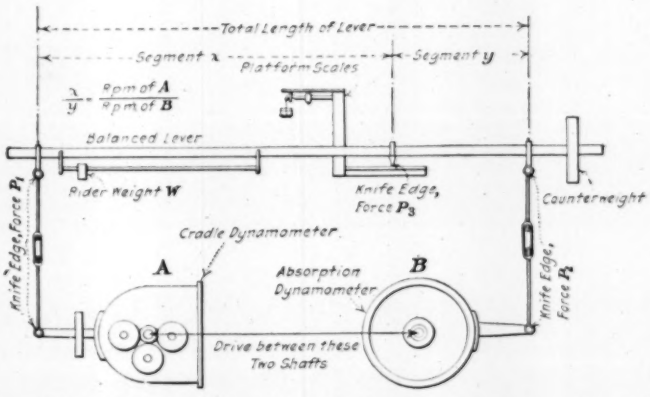

FIG. 1 GENERAL LAYOUT OF APPARATUS SHOWN IN FIG. 2

another purpose and the measurement is recorded in feet measured by an ordinary rule.

It is necessary to read the values recorded in column 10 with as great accuracy as possible, but the approximate distance to the mean position as determined in column 10 is as close as it is necessary to record the values of column 5.

The values in column 10 after correction for speed give the total loss in power and become therefore the whole of the numerator of the equation for *loss* of efficiency, namely,

$$\text{Loss of efficiency} = \frac{\text{Hp. loss}}{\text{Hp. input}}$$

These values for hp. loss are recorded to three significant figures, but the third is somewhat in doubt, and therefore the absolute accuracy is only through two significant figures.

In figuring hp. input it is necessary to use the value P_1, which is obtained by means of the equation $P_1 = 0.2122P_2 + 0.759x$, where x is the value in column 5. The maximum variation in feet from the mean position (column 10) is less than 0.1 ft., but suppose that it was 0.1 ft.; then column 5 might have been 1.8 instead of 1.7 as in the first recorded line.

To see what the effect of such a discrepancy would be,

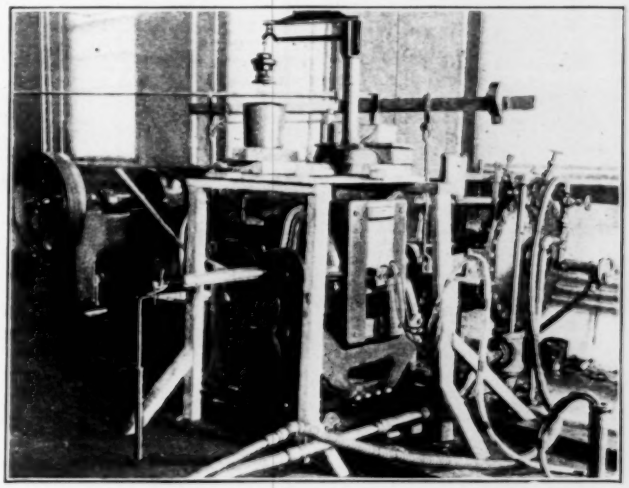

FIG. 2 APPARATUS FOR TESTING THE EFFICIENCY OF BEVEL-GEAR DRIVES

the following computations have been made, taking $x = 1.8$ and $x = 1.7$, respectively:

$P_2 = 200$; $0.2122P_2 = 42.44$

$P_1 = 42.44 + 0.759x$

$= 42.44 + (0.759 \times 1.8)$ or $= 42.44 + (0.759 \times 1.7)$

$= 42.44 + 1.36$ or $= 42.44 + 1.29$

$= 43.80$ or 43.73.

As hp_{1000} input = ½ P_1, then hp_{1000} equals either 21.90 or 21.865, and

$$\frac{\text{Hp. loss}}{\text{Hp. input}} = \frac{\text{Rider } hp_{1000}}{\text{Input } hp_{1000}}$$

whence

$$\text{Loss of efficiency} = \frac{0.746}{21.90} \text{ or } \frac{0.746}{21.865}.$$

It is thus seen that, measuring as accurately as possible, the numerator is only accurate to the second place, the third being in doubt; and that the second place in the denominator is sure, and the third fairly sure, although considered in doubt. Therefore the denominator is as accurate as the numerator.

The numerator is as accurate as the apparatus will allow data to be read, and therefore the inaccuracy of the data of column 5 has no effect on the final accuracy of the work.

In Test No. 1, the data of which are given in Table 1, practically no lubrication was used, the gears having been washed off with gasoline. Previous to this there had been oil and graphite on the gears, and some of the graphite still remained on the teeth. However, after running for a while they were practically non-lubricated. The 3-lb. rider had to be used in this case because of the amount of the friction loss, which, by the way, was sufficient to cause the gears to heat considerably.

Table 1 gives only a few of the results actually obtained, for

the apparatus was started time after time and the balance by the rider gave the same results over and over again.

The next test was made to see how much the efficiency would be increased with good lubrication. Accordingly some heavy oil and flaked graphite were mixed and used as a lubricant. The efficiency was so much increased that the 1½-lb. rider weight was sufficient, and again it was found that the same results were obtained time after time. Later, after the graphite and oil had become more perfectly blended, another test was made.

The efficiency curves for these three tests are all given in Fig. 4. The difference between the results of non-lubricated and lubricated conditions is perfectly clear. The test with the more perfect blending of the lubricant showed results identical with the previous one, except as indicated by the dash line at the end of the upper curve. This showed that the lubricant

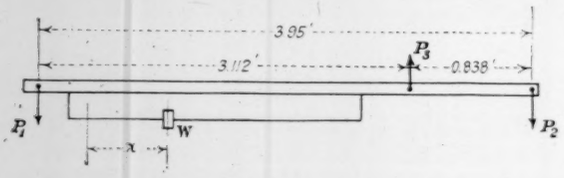

FIG. 3 DIMENSIONED SKETCH OF APPARATUS

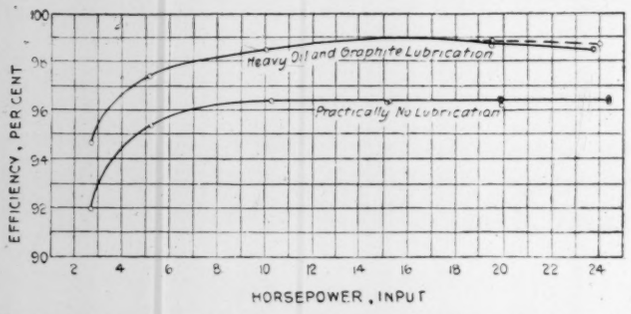

FIG. 4 HORSEPOWER-EFFICIENCY CURVES OF BEVEL-GEAR DRIVE

Gear ratio, 26 to 7; r.p.m. of pinion, about 1200

was not squeezed out from between the teeth at quite so low a pressure.

The form of the curves and the consistency of the readings convinced the experimenters that very reliable results had been obtained. This was also the case regarding tests made of the efficiency of a worm-gear drive and reported in the complete paper.

It is accordingly concluded that this apparatus will measure accurately the efficiency of any positive shaft drive where both shafts are rotating at constant speed, and that it seems to be the best method yet devised for testing gear drives for efficiency, since it measures directly the actual power loss.

While this paper has described only tests of bevel- and worm-gear drives, tests of other drives have been made, and the method is applicable to all types.

The depth of a pile seems to have a good deal to do with the development of spontaneous combustion. A 10-ft. pile is very likely safe for most bituminous coals, provided other conditions are not unfavorable; but 20 to 25 ft. is probably more or less dangerous. In the New York Edison Co.'s yard at Shadyside, N. J., where coal is stored in piles reaching heights up to 35 ft., spontaneous combustion gives trouble. (*Power*, April 16, 1918, p. 537)

A FOUNDRY COST AND ACCOUNTING SYSTEM

BY WILLIAM W. BIRD, WORCESTER, MASS.

Member of the Society

THE work in Shop Management at the Worcester Polytechnic Institute is in the nature of a laboratory course, and experimental work in accounting and cost keeping is made possible by the commercial foundry and machine shop of the Institute, known as the Washburn Shops.

The object of this paper is to present an outline of the cost and accounting system which has been developed as a result of experiments carried on in connection with the foundry at the Institute.

The first problem was to determine the number of independent variables and how the dependent ones were related to them. After several years it was decided that the three most important items were Core Labor, Molding Labor, and Pounds of Castings Produced, and that each of the other items of cost was a function of some one of these three independent items.

Ledger accounts were opened for each one of the items, and by careful inventories at the beginning and end of each year the exact annual cost for each item was worked out.

The next problem was to determine a proper production credit for the individual accounts for each month, based on factors secured by previous records. The general scheme being to charge an account with the amount of the purchases for that month and credit it with a fair estimate of what ought to have been used for that month's work. These production credits are charged to another account, as will be explained later.

All expenses are charged to the Expense Account and the production credit for expense ought to be large enough to more than balance the charges, thus creating a balance to the good, known as Expense Reserve.

CORE WORK

The material required for core work was found to average about 30 per cent of the core labor, hence to make the production credit for core work for a month it was only necessary to secure from the payrolls the amount paid to the core makers for that month and add 30 per cent for the supplies used.

MOLDING

All of the items of cost in the foundry excepting the metal, melting and core work, were divided into two classes: Supplies or all the materials used in connection with molding, such as sand, facing, etc., and Expense, or all charges for management, office work, power and other overhead items, cleaning, flasks, etc.

At the present time we are basing our production credits for supplies on 6 per cent of the molding labor and the expense on 75 per cent, the molding labor for the month being secured from the payrolls, all of the molders being grouped for this purpose.

METAL AND MELTING

In order to secure the exact tonnage for each month it was

For presentation at the Spring Meeting, Worcester, Mass., June 4 to 7, 1918, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form and advance copies of the paper may be obtained by members gratis upon application. All papers are subject to revision.

found necessary to make an inventory on the first of each month of the castings on hand. This, however, is only a close estimate of the weight of these castings. A record of the castings sold during the month gives the tonnage also. Correcting this for the change in the inventory of castings, gives the production in pounds for the month.

The cost of melting was found to vary directly with the pounds of castings produced, and therefore the melting production credit for the castings produced each month is found by multiplying the pounds produced by the melting factor, which at present is 30 cents per 100 lb.

A careful record for a number of years of the castings produced and of the pig and scrap used, gives the data for the factors to be employed in making up the production credits for the metal used each month. At present we use 75 per cent of the pounds produced as the proper weight of pig iron, and 37½ per cent for scrap iron. These factors take care of the shrinkage and the defective castings, as these are replaced without credit to the foundry.

Knowing the weight and cost of the pig iron purchased each month, this cost including all charges for freight and teaming, the cost per 100 lb. is made up. Multiplying this by 75 per cent of the pounds produced, we have the production credit for pig iron. The production credit for scrap iron is worked out in the same way.

The problem of handling the difference between the material purchased and what was actually used was solved by making the ledger balance a book inventory for material accounts and a reserve for the expense account, as stated.

The next problem of how to adjust the difference between the castings sold and the castings produced was solved as follows:

Two ledger accounts were opened—Foundry Sales and Foundry Production. The first is credited with the monthly sales and charged with the factor cost of the castings sold. The balance of this account is the factor gain and gives a definite line on the profits.

Foundry Production is charged each month with the total amount of the production credits and credited with the factor cost of the castings sold, the monthly ledger balance giving the value of the castings on hand. In fact, the value of the castings on hand is worked up first from the inventory made on the first of each month, and the factor cost of castings sold is simply the amount required to make the account show the proper balance.

To show the exact working of this system, the figures for three months will be given—a good month, a fair month, and a poor one. As these months did not come in this exact order, it was necessary to make a few changes in the figures, but they are substantially an exact record.

Starting with a clear record on July 1, with no castings on hand, we have:

BALANCE SHEET, JULY 1

ASSETS		LIABILITIES	
Bills receivable	$13,187.20	Capital	$20,000.00
Cash	6,331.06	Surplus	3,654.13
Metal and supplies	1,333.03	Bills payable	2,197.16
Equipment	5,000.00		
	$25,851.29		$25,851.29

The inventory on August 1 gave 3500 lb. of castings on hand, the sales record gave 122,541 lb. sold, the production was therefore 126,041 lb. The core labor was $443.89 and the molding labor $1863.84. 117,180 lb. of pig iron cost $2381.86 and the scrap iron cost $1.50 per hundred delivered in the yard. These are all of the data necessary for making up the following:

MONTHLY FOUNDRY RECORD, JULY

Purchases	Division	Factor	Production credits
$443.89	Core labor	100%	$443.89
127.00	Supplies	30%	133.17
1,863.84	Molding labor	100%	1,863.84
156.29	Supplies	6%	111.83
1,303.03	Expense	75%	1,397.88
612.17	Metal—melting	30c.	378.12
2,381.86	117,180 lb. pig iron	75%	1,918.98
737.62	$1.50 per 100 scrap iron	37½%	708.98
$7,625.70	Total—Factor Cost of Production		$6,956.69

The factor cost was $5.52 per 100 lb. for castings produced and the castings on hand at the end of the month were valued at this rate. 3500 lb. at $5.52 gives a correction of $193.20. This is the difference in the value of castings on hand at the beginning and end of July.

Factor cost of production	$6,956.69
Correction	193.20
Factor cost of castings sold	$6,763.49
Sales for July	7,350.31
Factor gain for July	$586.82

The Expense Reserve is found by subtracting the charges $1303.03 from the credits $1397.88, giving $94.85 for the month.

The Trial Balance of the Ledger gives the necessary data for the following:

BALANCE SHEET, JULY 31

ASSETS		LIABILITIES	
Bills receivable	$13,288.31	Capital	$20,000.00
Cash	6,299.50	Surplus	3,654.13
Castings	193.20	Bills payable	2,342.10
Metal and supplies	2,096.89	Expense reserve	94.85
Equipment	5,000.00	Factor gain	586.82
	$26,877.90		$26,877.90

On September 1 we had 4000 lb. of castings on hand, and sold in August 132,773 lb. The production was therefore 133,273 lb., as we had 500 lb. more on hand at the end of the month than at the beginning.

MONTHLY FOUNDRY RECORD, AUGUST

Purchases	Division	Factor	Production credits
$522.61	Core labor	100%	$522.61
45.50	Supplies	30%	156.78
1,968.90	Molding labor	100%	1,968.90
44.83	Supplies	6%	118.13
1,426.64	Expense	75%	1,476.67
382.21	Metal—melting	30c.	399.82
2,759.65	107,620 lb. pig iron	75%	2,568.84
701.70	$1.75 per 100 scrap iron	37½%	874.62
$7,852.04	Total—Factor Cost of Production		$8,086.37

Inventory correction	$49.60
Factor cost of castings sold	$8,036.77
August sales	8,179.51
Factor gain—August	142.74
Factor gain—July 1-Aug. 1	586.82
Factor gain—July 1-Aug. 31	$729.56

The Expense Reserve for August is $1476.67 minus $1426.64, or $50.03, making the total Reserve, August 31, $144.88.

BALANCE SHEET, AUGUST 31

ASSETS		LIABILITIES	
Bills receivable	$14,016.50	Capital	$20,000.00
Cash	5,750.82	Surplus	3,654.13
Castings	242.80	Bills payable	2,394.14
Metal and supplies	1,912.59	Expense reserve	144.88
Equipment	5,000.00	Factor gain	729.56
	$26,922.71		$26,922.71

On October 1 we had 15,000 lb. of castings on hand and sold during September 124,557 lb. The production for the month was therefore 135,557 lb.

MONTHLY FOUNDRY RECORD, SEPTEMBER

Purchases	Division	Factor	Production credits
$542.00	Core labor	100%	$542.00
65.46	Supplies	30%	162.60
2,016.70	Molding labor	100%	2,016.70
144.94	Supplies	6%	121.00
1,326.58	Expense	75%	1,512.33
541.90	Metal—melting	30c.	406.67
2,834.85	116,980 lb. pig iron	75%	2,460.37
1,763.52	$1.75 per 100 scrap iron	37½%	889.60
$9,235.95	Total—Factor Cost of Production		$8,111.47

Inventory correction	$654.20
Factor cost of castings sold	$7,457.27
September sales	7,485.76
Factor gain—September	28.49
Factor gain—July 1-Sept. 1	729.56
Factor gain—July 1-Sept. 30	$758.05

The Expense Reserve for September is $1512.53 minus $1326.58, or $185.95, which added to $144.88 makes the total reserve $330.83.

BALANCE SHEET, SEPTEMBER 30

ASSETS		LIABILITIES	
Bills receivable	$13,378.81	Capital	$20,000.00
Cash	5,374.27	Surplus	3,654.13
Castings	897.00	Bills payable	3,130.09
Metal and supplies	3,223.02	Expense reserve	330.83
Equipment	5,000.00	Factor gain	758.05
	$27,873.10		$27,873.10

In order to keep comparative data before the foundry officials and aid them in the analysis of the monthly records, the table of monthly averages (in the next column) is filled in as soon as possible after the first of each month.

In order to keep a line on the book inventories, the table following that of monthly averages is filled in each month. These figures show the changes in the several accounts and indicate in a way how the factors are working. If an account is steadily growing, as the Pig Iron Account shows in this table, we are either accumulating pig iron or the factor is too small. Core Supplies here shows a constantly diminishing amount, and either we are reducing our supplies or the factor is too large. An exact inventory can be made at any time to check up the book inventory and a change made in the factor if necessary.

MONTHLY AVERAGES

	Previous year	July	August	September
Production, lb.	138,605	126,041	133,273	135,557
No. of heats	24.5	24	24	25
No. of molder days	442	467	478	493
Weight per heat, lb.	5670	5250	5550	5420
Weight per molder day	314	270	279	275
Cost of molding	$1,644.82	$1,863.84	$1,968.90	$2,016.70
Avg. pay per molder day	$3.72	$4.00	$4.12	$4.09
Core work per 100 lb.	0.42	0.46	0.51	0.52
Molding and expense	2.14	2.68	2.67	2.69
Melting and metal	1.53	2.38	2.89	2.77
Production cost	$4.09	$5.52	$6.07	$5.98
Inventory correction			0.02	0.01
Cost of castings sold	$4.09	$5.52	$6.05	$5.99
Selling price	$4.36	$6.00	$6.16	$6.01
Factor gain	0.27	0.48	0.11	0.02
Sales total	$6,083.60	$7,350.31	$8,317.51	$7,542.46
Factor gain month	$375.46	$586.82	$142.74	$28.49
Per cent gain	6.2	8.0	1.7	0.4
Expense reserve	$37.00	$94.85	$50.03	$185.95
Rating	Good	Good	Fair	Poor

INVENTORIES—METAL AND SUPPLIES

MONTHLY CHANGES

	July	August	September
Core supplies	−6.17	−111.28	−97.14
Molding supplies	+44.46	−73.30	+23.94
Melting supplies	+234.05	−17.61	+135.23
Pig iron	+462.88	+190.81	+374.48
Scrap iron	+28.64	−172.92	+873.92
Net change	+763.86	−184.30	+1,310.43
Beginning of month	$1,333.03	$2,096.89	$1,912.59
End of month	$2,096.89	$1,912.59	$3,223.02

The following samples of ledger pages will show just how the bookkeeping is done:

FOUNDRY SALES

July 31	Factor cost—sales	$6,763.49	July 31	Sales	$7,350.31
	Balance	586.82			
		$7,350.31			$7,350.31
			Aug. 1	Balance	586.82

The balance of this account gives the factor gain and is the total amount from the beginning of the fiscal year.

FOUNDRY PRODUCTION

Aug. 1	Balance	$193.20	Aug. 31	Factor cost—sales	$8,036.77
31	Factor cost—production	8,086.37		Balance	242.80
		$8,279.57			$8,279.57
Sept. 1	Balance	242.80			

The balance on this account is the exact inventory of the castings on hand, valued at the factor cost for the month.

FOUNDRY EXPENSE

Sept. 30	Purchases	$1,326.58	Sept. 1	Balance	$144.88
	Balance	330.83	Sept. 30	Production credits	1,512.53
		$1,657.41			$1,657.41
			Oct. 1	Balance	330.83

The balance on this account is the amount that the Reserve has built up during the year.

PIG IRON

July 1	Balance	$331.20	July 31	Production credit	$1,918.98
July 31	Purchases	2,381.86		Balance	794.08
		$2,713.06			$2,713.06
Aug. 1	Balance	794.08			

The balance on this account is the book inventory for the pig iron on hand.

Thus every ledger balance has a definite meaning, either an inventory, a reserve or a gain, and the complete balance sheet for each month can be made up in a few minutes from the regular trial balance. All of the work can be done by the regular clerical force and requires but a small amount of extra time. No expert accountant or efficiency engineer is needed.

The closing of the books at the end of the fiscal year introduces several interesting problems.

The Molding and Core Labor Accounts take care of themselves as the charges and credits are the same and they are therefore always balanced. The material accounts are first corrected by introducing the exact value of a carefully made inventory. This gives us the real cost for the material which has been actually used during the year. The next step is to adjust the production credit for the twelve months to the final charge. The difference between the two sides of the ledger is the amount of the adjustment and may be either plus or minus. The net result of all these factor adjustments is carried to Expense Reserve and will either increase it or decrease it, as the case may be.

Bad accounts, depreciation charges, discounts, premiums, special expenses or any other accounts which need to be absorbed, are all transferred to Expense Reserve and the net balance of the account is carried to Foundry Sales either increasing or decreasing the Factor Gain and this balance then becomes the real Sales Gain for the year.

In conclusion, we would say that the system as outlined is giving good satisfaction, the results are fairly accurate, and the comparative monthly data thoroughly reliable as a signal system.

A state testing and experimental institution for the mining industry has been formed in Minneapolis, Minn., and it will coöperate with the mining section of the University of Minnesota. Special attention will be paid to the treatment of ores with a comparatively low percentage of iron, and which at present cannot be industrially exploited with advantage, so that such ores may be enabled to play their part in the iron industry of the country. Particular attention will be paid to hematite containing 30 per cent to 50 per cent iron, to magnesite iron and to titaniferous iron ore, of which large deposits are to be found in the northeastern portion of Minnesota, and to manganese ore with a small percentage of manganese—all problems of great importance to the future of the American iron industry.

INVESTIGATION OF THE USES OF STEAM IN THE CANNING FACTORY

By JULIAN C. SMALLWOOD, BALTIMORE, MD.

Member of the Society

IT is not the writer's purpose to deal in this paper with the economies possible in the generation of steam in the canning factory. Although it would well repay the packer to inform himself on this subject, since in the boiler room any amount up to 50 per cent of his coal may be wasted, the principles of economical boiler-room operation are well understood by mechanical engineers and are no different in the canning factory from any other. The principles and the best practice in the use of steam, on the other hand, are not common knowledge, and will therefore engage the writer's attention.

USES OF STEAM IN CANNING FACTORIES

First in an enumeration of the various packing-house units requiring steam are engines to turn the lineshaft and operate cranes and conveyors, and, possibly, pumps for supplying water. Next in order is the apparatus to give the raw material a preliminary heat treatment. In the case of tomatoes, this is a scalder which loosens the skins; in the case of peas, beans, spinach, etc., it is a bleacher which fixes the color of the product and washes away impurities and partial decay. At this stage some goods are placed in the cans, but for others heat must first be applied in bulk in order to evaporate water and concentrate the product. For example, tomato pulp or paste must first be boiled down, as must also fruit juices in the manufacture of jellies and preserves. If the material requires such reduction, it is next introduced into a kettle supplied with a steam jacket for evaporation, or a tank supplied with steam coils, or into some form of evaporator using steam as a source of heat for evaporation. If the material does not require such reduction, it must next be sent through an exhaust box the chief function of which is to produce a partial vacuum in the capped can by expanding its contents previous to capping. The expansion is accomplished by heating the cans by direct contact with steam in the exhaust box. After the cans are capped they are packed in metal cages and placed in a "process kettle" or retort, where they again are subjected to steam heat for the purpose of sterilizing and cooking. Finally, upon removal from the process kettles, the packed cans must have their heat removed, which is usually effected by a water bath and which completes the heat processes of production.

ANALYSIS OF THE HEAT DISTRIBUTION

An analysis of the heat distribution leads to the following conclusions: First, as a rule, the mechanical power required is comparatively small, and this limits the possibilities of exhaust steam. Second, except for products that must be reduced by evaporation, the directly useful heat functions simply by elevating the temperature of the raw material from that of the room up to whatever temperature is carried in the process kettle. Assuming, for example, that the temperature of the

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For presentation at the Spring Meeting, Worcester, Mass, June 4 to 7, 1918, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form and advance copies of the complete paper may be obtained by members gratis upon application. All papers are subject to revision.

raw material is 80 deg. fahr. and the temperature of the process kettle is 212 deg., the difference is 132 deg., and the useful heat in the whole process of canning is numerically equal to the total weight of the can contents multiplied by 132 deg. multiplied by the specific heat. To this, of course, must be added the heat of vaporization when the product is reduced, which, however, is only the case for certain products.

This may seem a startlingly simple conclusion to be formed from a complex problem, and yet, truly, there is no other one. Cooking and sterilizing are merely a matter of ele-

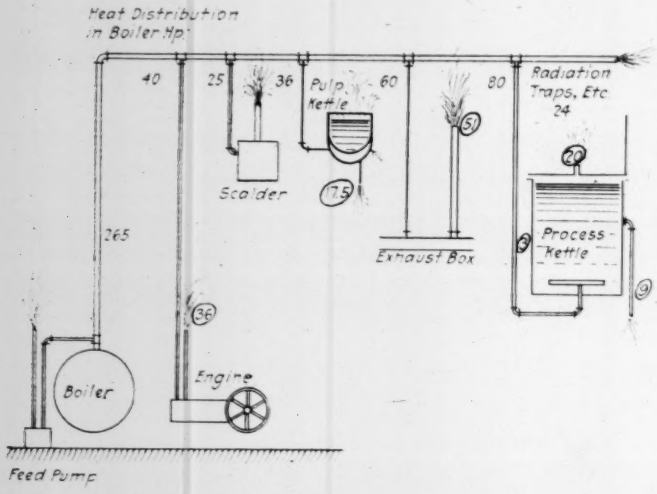

FIG. 1 DISTRIBUTION OF HEAT IN A FACTORY CANNING TOMATOES

vating a temperature and maintaining it. Once the temperature is attained it can be held, under ideal conditions, without further consumption of heat. Heat consumed for any other purpose is either for an auxiliary process, or is a total loss through inefficiency of the main process. This principle finds an application in a small way, in domestic kitchens, in the fireless cooker. The old-fashioned stove and the more recent gas range both waste enormous amounts of heat, because after the temperature of the cooking material has been raised, heat continues to be consumed, and is wasted by radiation from the containing vessel and by convection currents.

Similarly, in the canning factory, from the time the raw material enters the exhaust box up to the time it leaves the process kettle, the one desirable effect is the elevation of temperature. In the exhaust box this is partially accomplished, possibly with the expenditure of a disproportionate amount of steam. Between this stage and the process kettle the can is being capped and packed in the crates, during which handling it may radiate some heat which will have to be restored. Finally, the sealed cans are placed in the process kettle. Heat is transferred to them and, incidentally, radiated from the surface of the kettle, blown right through the kettle (especially if an open water bath is used), and wasted through an overflow of hot water.

For the purpose of obtaining an idea of the quantitative values of these heat transfers, Fig. 1 has been prepared showing the distribution of heat in a packing house putting up tomatoes. An arrangement using steam inefficiently has been purposely shown in order to indicate the possibilities. It is assumed that this plant is equipped to handle 10,000 baskets per day of 12 hours, that the tomatoes are canned whole, and that skin-and-core pulp is put up as a by-product. A fair value for the yield is seven No. 3 cans of whole tomatoes per basket, and one No. 3 of pulp. This will make a total of 70,000 cans of the former and 10,000 cans of the latter per day of 12 hours.

Taking as the heat unit the boiler horsepower, which is equivalent to about 30 lb. of high-pressure steam per hour, or, more exactly, 33,479 B.t.u. per hr., and assuming the temperature elevation to be 132 deg., the useful heat added to the whole tomatoes amounts to 57.5 boiler hp. The pulp must not only be elevated in temperature but thickened by evaporation of some of its water. Assuming a reduction of 5:4, the boiler hp. necessary is 18.5, making a total of 76.

Of the useful heat to the whole tomatoes only 9 boiler hp. is added in the exhaust box, the remainder being added in the process kettle. The figures on the drawing enclosed in circles represent the waste heat either through exhaust steam, or hot water from drains, or radiation.

These heat quantities may seem excessive, but it should be remembered that they vary in each of the particulars very considerably in different plants. The distribution shown may be considered on the whole not unrepresentative.

A study of this example shows that there are two general methods of obtaining heat efficiency in the use of steam. First, by improvements in the construction and operation of heat-transfer apparatus, and second, by establishing a coördination of units so that what has ordinarily been considered as waste and irrevocable heat may be recovered to the fullest extent possible. These requirements do not exist independently. Let us then consider first the efficiency, or lack of efficiency, of the various steam-using units familiar in the canning factory, having special regard to the possibilities of eliminating steam wastes, and with all due respect to the paramount necessity of capacity.

BLANCHERS AND SCALDERS

Blanchers and scalders both make a heavy drain on the steam pressure. In their operation water and steam are led to a single chamber, circular or rectangular in cross-section, through which also the vegetables or fruit are fed. In blanchers

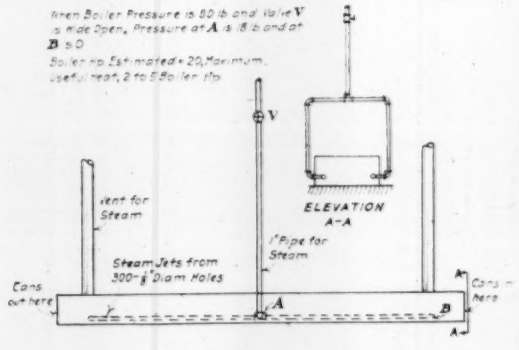
When Boiler Pressure is 80 lb. and Valve V is Wide Open, Pressure at A is 18 lb. and at B is 0
Boiler hp. Estimated = 20, Maximum useful heat, 2 to 5 Boiler Hp.
V
Vent for Steam
ELEVATION A-A
1" Pipe for Steam
Steam Jets from 300-#" Diam. Holes
Cans out here
Cans here
A
B
A

FIG. 2 HOME-MADE FORM OF EXHAUST BOX

the steam heats the water which is constantly overflowing, and excess steam is carried through a vent flue to the roof. Upon meeting the hot water, the raw material is washed free of its gummy coating, etc., which gradually contaminates the water and necessitates a continuous supply. The incoming fresh water requires more steam to maintain the temperature. Furthermore, steam must be added in sufficient amount to counteract the cooling effect of the entering food. From these considerations it becomes apparent that an exercise of judgment

is required to regulate the water and steam supply to the rate of the food material to secure the best economy with steam. The water should be fed in just fast enough to maintain the minimum degree of purity consistent with the requirements. Any greater amount of water necessitates more steam, the heat of which is wasted through the overflow. Any greater amount of steam than is necessary to maintain the temperature merely blows through the vent flue. Obviously, two or three times as much steam as is necessary may be consumed if regulation is neglected.

In the operation of tomato scalders a similar conclusion may be drawn. Here the steam and water do not mix, that is, intentionally, it being the purpose to have first the steam and then the cold water strike the raw material. Steam at 80 to 100 lb. pressure is supplied through a 2-in. pipe and passes through a series of perforated holes in pipes placed above and below a conveyor chain carrying the tomatoes. The bed of fruit is something like four to six inches thick, and it is expected that these steam jets will penetrate the mass and heat their outer skins in about ten seconds. Now, in the same chamber in which the steam is working, and just beyond the steam jets, are jets of cold water. There is no dividing partition, and the result is a splendid condenser effect. As the water must be kept cold, more of it than otherwise necessary is turned on to counteract this effect, thereby enhancing it. Provision is made through a vent flue so that if any steam escapes both water and tomatoes, it can go out through the roof.

Obviously, with the application of ingenuity and experiment the steam consumption of these machines might be materially lessened through radical structural changes without impairing effectiveness or capacity. On the other hand, and opposite to the case of bleachers, it is difficult to secure steam economy by nice regulation alone—for one reason because of the prejudice of operators.

Exhaust Boxes

Exhaust boxes are now to be considered. In the home-made form (see Fig. 2) these are long rectangular boxes made of four planks, open at the ends, and through which a conveyor

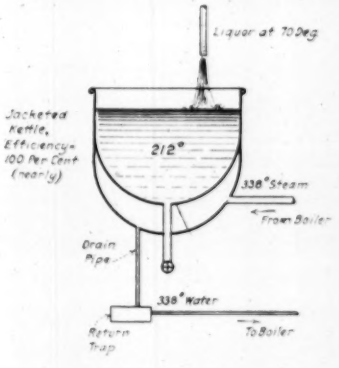

Fig. 3 Jacketed Kettle

chain passes bearing the filled but uncovered cans. Drilled pipes within the box are used as steam jets playing on the cans. At the ends of the box are flues, so that when the steam is fully turned on it will not pass into the packing room but out through the roof.

It is at once apparent that it is out of the question to obtain anything like a uniform temperature of the can contents in the small space of time that they are subjected to the steam, particularly if they are packed closely and contain little liquid. The heat consumed in the form of steam may be as much as anything between 20 and 30 boiler hp., making for a thermal efficiency of about 10 to 15 per cent. Where does the difference go? Through the roof.

The performance of the exhaust box as regards steam economy may be materially bettered by the careful regulation of the steam supply. From trials which the writer has made, involving temperature and pressure measurements, he has found that the steam can be cut down from full on to about one-half a turn of the stop valve in some cases without materially affecting the temperature elevation. That is, the heating effect is nearly as good when the steam merely trickles through

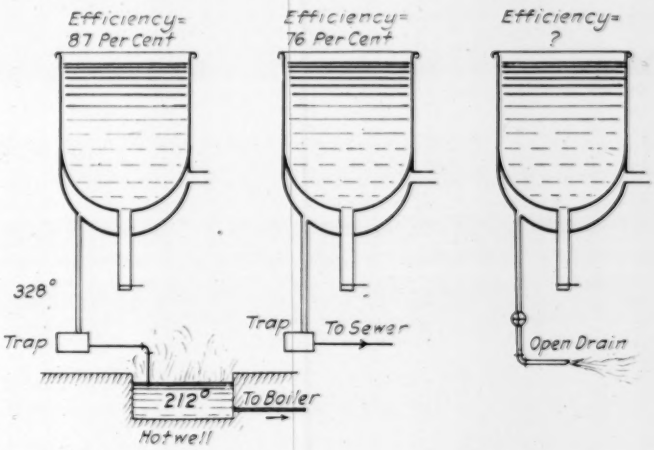

Fig. 4 Various Ways of Handling Steam in Connection with Jacketed Kettles

as when it pours through. To gain effectiveness, the time during which each can is subjected to the steam must be lengthened, and the greater the time, the greater will be the machine's efficiency. This fact is being recognized by the manufacturers of modern forms of exhaust box, which are so shaped that the length of the path through them is greatly increased, thereby increasing the time of heating (to 5 and 15 min.).

Much can be gained if the exhaust box is in part relieved of its effort by introducing whatever liquor goes with the solid part of the contents as hot as may be.

Jacketed Kettles

Turning now to a consideration of the various packing-house units used for concentrating liquid foods and food juices, which units may be termed generally "evaporators," it will be noted that there are many different forms and types. Perhaps the most elementary form, and in some ways the most interesting, is the jacketed kettle (see Fig. 3). It has a capacity of between 50 and 500 gal., and instead of having heat applied to it as an open flame, receives it from the steam jacket whence it gets its name. The jacket is tapped with one or more openings to receive the steam pipes, and another opening for the drain pipe to carry off the condensed steam.

The performance of these kettles is very interesting in many ways. In the first place, it may be observed that under approximately ideal conditions their thermal efficiency may be nearly 100 per cent, the only loss being from radiation of heat from the outside of the jacket. This assumes that the condensate from the jacket is returned to the boiler through a return trap which, however, is not always—or even often—used. Steam at 100 lb. gage pressure has a temperature of 338 deg., so if steam of this pressure is used in the jacket

of a kettle it will, after condensing in the jacket, emerge from the drain pipe as water at 338 deg. If this hot water is returned to the boiler by a return trap, none of its heat is lost (except that small amount due to radiation), and practically all of the heat given up by the steam goes to the useful purpose of evaporating water from food material.

There are, however, three other ways in which steam may be handled (see Fig. 4). First, the drain may be passed through an atmospheric trap, which necessitates that the water be reduced to below 212 deg. before it can be returned to the boiler. In this case the efficiency of the system is 87 per cent, and 13 per cent of the heat consumed is wasted. Practically the same thing may be accomplished if the drain pipe is without a trap but is supplied with a stop valve so regulated that only water will be discharged. Second, the kettle may be supplied with an atmospheric trap, or a stop valve in the drain pipe as just described, the discharge from which is *not* returned to the boiler. In this case, if feedwater at 70 deg. is used to make up the 212-deg. water which might have been used, the waste is 24 per cent and the efficiency only 76 per cent. Third, the kettle may be unprovided with a trap of any kind, and the valve in the drain pipe left so wide open as to let large quantities of steam escape as well as condensate. Here it is difficult to estimate the ensuing waste, but if one is to judge by the ascending clouds of steam, it must be enormous.

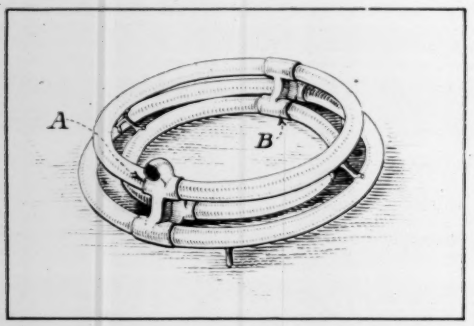

FIG. 5 EVAPORATOR COIL OF MODERN DESIGN

A jacketed kettle in full blast shows the most haphazard ebullition, and one would suppose that a much more effective rate of evaporation could be obtained if the circulation could be assisted. In spite of this, the fact is that this apparatus is a remarkably quick evaporator. Results that have come to the writer's attention show, with the use of 100-lb. steam, as high as 8.5 gal. or 70 lb. of liquid evaporated per square foot per hour after the mass has come to a boil. This corresponds to about 700 B.t.u. of heat transferred per hour per square foot per degree difference of temperature, a figure comparing very favorably with the best types of feedwater heaters and condensers, which class of steam-engineering apparatus the jacketed kettle most closely resembles as regards the matter of heat transfer.

Jacketed kettles, differently installed, show very different capacities for evaporation. The question then arises, What are the factors affecting the rate of evaporation? A study of this question shows that the total amount of water a kettle can evaporate per hour may be affected chiefly by the pressure of the steam in the jacket. The rate of heat transfer is directly proportional to the difference in temperature between the boiling material (about 212 deg.) and the substance supplying the heat, that is, the steam. Now, since the temperature of steam increases with its pressure, the high-pressure steam is more effective in rapidity. But if the steam pipes are too small, or if the kettle opening for steam is not large enough, there may be a considerable drop of pressure of the steam before it reaches the jacket, and a still further drop after it gets into the jacket. In consequence, and especially if the steam is initially wet, it falls in temperature and loses some of its effectiveness. Much can be done to improve capacity by using carefully calculated pipe sizes and by *introducing the steam into the jacket through two or more openings instead of only one*. A series of experiments with the purpose of learning the pressure within a steam jacket for different systems of piping would, it is felt, disclose facts of practical value in future design.

The capacity of a jacketed kettle may be much reduced by the cooking material caking to its sides. To avoid this condition, kettles are frequently equipped with mechanical stirrers which continuously wipe the heating surface, thus keeping it clean. This action also imparts a velocity to the boiling liquid at the heating surface which, presumably, affects the heat transfer, but just how much is not known. Similarly, the quantitative effect of high velocity of the steam in the jacket is unknown.

COIL EVAPORATORS

The final limitation to capacity has to do with the area of the heating surface. The obvious step, then, is to add heating surface in order to increase capacity, and this has been done.

Coils offer such an attractive way of forming a compact heating surface, that they have come into favor in units which dispense entirely with the steam jacket. Any form of containing vessel may be used for the liquid to be concentrated, and the vessel may be made of any appropriate material. Jacketed kettles are commonly made of copper: the containing vessels for coil evaporators may be made of wood, thereby making a great saving of expense. Also, a wooden vessel with coils occupying a given floor space may contain vastly more heating surface than a jacketed kettle occupying the same floor space, and therefore have considerably greater capacity. In such a case the coil evaporator also loses less heat by radiation from the containing shell, but otherwise the heat efficiency of the coil may be just as good or as bad as that of jacketed kettles previously cited. The effectiveness of a single square foot of heating surface of the coil is, it is believed, possibly less than that of the jacket, particularly if the coil is not carefully designed. "Effectiveness" in this connection means the number of heat units that can be transferred per hour from the steam to the liquid contents. As mentioned before, the efficiency may be nearly 100 per cent in each case.

Fig. 5 shows a coil of modern design taking steam through the manifold at *A* and exhausting from drain *B*.

Evaporators depending upon coils or nests of tubes suffer two serious disadvantages: First, they are much more difficult to clean and to keep clean than are jacketed kettles. Mechanical wipers, as stirrers, are out of the question, and hand cleaning is awkward. Second, they are, with poor design, more apt to leak steam into the liquid to be evaporated than are jackets, whereby both heat and capacity are lost.

VACUUM PANS

In the writer's opinion, a type of evaporator which will eventually enter the canning factory is the vacuum pan, Fig. 6. The advantage which it possesses is that it can use exhaust steam efficiently, and, when live steam is employed, the pan may be so designed as to take only half or less than half the

steam required by apparatus which boils at atmospheric pressure.

The subject of vacuum pans is too large a one to enter upon here, there being many different designs and principles involved. It may be mentioned, however, that the whole subject is replete with unsolved problems which give much opportunity for successful research work.

All of the evaporators cited may meet a check in their capacity when certain products are handled, through the thickening and foaming of these products. To avoid boiling over, foaming necessitates a cutting down of the rate of evaporation. Similarly with thickening—the resulting increased viscosity of the mass causes a spattering dangerous to operators and wasteful of material. In such cases the initial rate of evaporation must be lessened toward the end of the process. The remedy is evaporators with high sides to prevent boiling over, and stirrers to prevent caking.

TABLE 1 PERFORMANCE OF EVAPORATORS

Type of evaporator	Evaporation, lb. per sq. ft. per hr.	B.t.u. transferred per sq. ft. per hr. per deg. fahr. difference in temperature
Jacketed kettle with 100 lb. steam pressure, by test	66.6	660
Jacketed kettle with 50 lb. steam pressure, assuming the same B.t.u. rate of transfer	45.0	
Jacketed kettle with 25 lb. steam pressure	29.0	
Shell evaporator, with paddles, 50 lb. steam pressure, by test	41.5	625
Coils, 100 lb. steam pressure, by test	60.0	628
Vacuum pan, single effect, 25 lb. steam pressure, on tomato paste; average, by test	40.0	313
Vacuum pan, maximum, 100 lb. steam pressure	105.0	600
Vacuum pan, with 10 lb. steam pressure, single effect, and 26 in. vacuum	64.5	600

Another item which should be carefully calculated for individual evaporators as well as a number of them together, is the drainage of the spaces supplying steam. It is very easily possible to food these spaces with water, either through too small a pipe size for the drain from the jacket or coil, or by having one unit flood another, or by a badly designed unit of which coils are a conspicuous example.

Comparative Performance of Evaporators

In Table 1 the first three lines show the effect of using steam of a lower pressure than 100 lb., the rate of evaporation in lb. per sq. ft. per hour rapidly falling off with the lower-pressure steam. The low result of the shell evaporator may be explained possibly by the effect of the design, in that the heating surface was so arranged that part of it could be flooded during operation. It is seen from the table that the best results were secured with the jacketed kettle. This fact is very much influenced by the steam connections, in that if only one is used, the rate of evaporation may be only half that obtained when two generous steam openings are used.

Table 2 is intended to show the real advantage of coils. The figures presented are obtained from a number of kettles and coils in actual operation. It is seen that as the capacity of the kettle increases the heating surface per unit of contents decreases, which is not true of the coil, the reason being that the jacket surface of the kettle increases with the square of its linear dimension, whereas the volume increases as the cube.

Process Kettles

The last item to be considered is the process kettle. In one way this is perhaps the most important of all, since the success of the pack depends upon the process kettle. Its whole function is to raise the temperature of the contents of the cans to that necessary for sterilization. Fig. 7 is a diagrammatic representation of a process kettle.

There are four methods in use in the operation of these units: First, the cans are placed in the process kettle, which is previously empty; the kettle is then closed and steam turned on so that a pressure of between 5 and 15 lb. gage is secured. Second, this same process may be used, except that the kettle

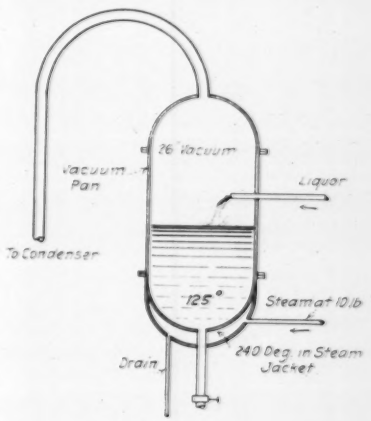

FIG. 6 VACUUM PAN

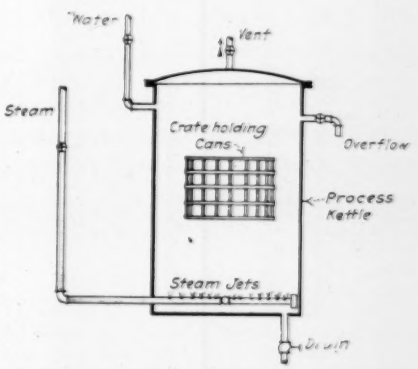

FIG. 7 DIAGRAMMATIC REPRESENTATION OF A PROCESS KETTLE

is previously filled with hot water and the cans are subjected to a water bath under pressure at a correspondingly high temperature. Third, the cans may be placed in a closed process kettle and subjected to a pressure very slightly greater than atmosphere, say, 1 lb. gage, there being no water in the kettle. Fourth, the process may be under atmospheric pressure but in a water bath with the lid of the kettle raised. These processes may be referred to as dry and wet, respectively, and closed and open.

In the open-bath process it is a custom of operators to maintain a violent boil of the bath so as to secure a circulation through all the interstices between the cans, which practice results in large volumes of steam being emitted into the packing room. In the closed process it is the custom to vent the valve on top of the kettle. When the process is wet, it seems that the object is twofold: first, to secure a circulation through the

interstices, and second, because it is easier to maintain a uniform temperature with the steam flowing through rapidly with this vent valve considerably open than to secure this uniform temperature with only a small vent.

Now, besides raising the temperatures of the cans in the dry process, heat has to be furnished to the kettle in the following directions, all of which is wasted:

1 To raise temperature of the metal of crates and kettle
2 To vent the kettle allowing air to escape, or to establish a circulation through the cans
3 Condensed steam drained from kettle
4 Radiation of heat from the outside surface of the kettle.

To these items, must be added, when the wet process is used, the heat necessary to raise the temperature of a mass of water

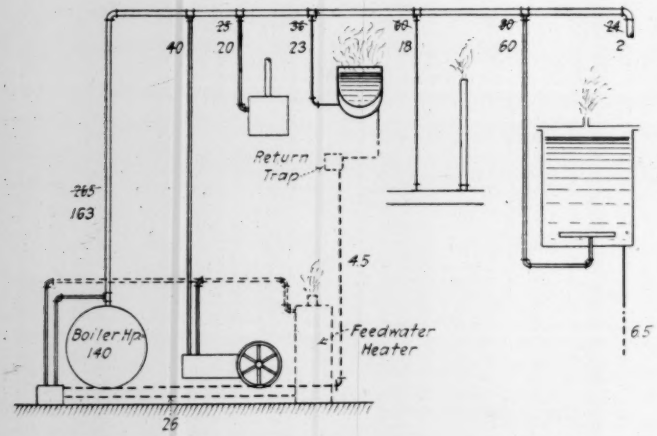

FIG. 8 POSSIBILITIES OF IMPROVING PERFORMANCE OF THE PLANT OF FIG. 1

as well as that of the cans. Table 3 gives some quantitative values, obtained in part by test, but for the most part by calculation upon the assumption of reasonably good conditions in each item. In this connection it should be remembered that radiation, venting and overflow wastes may each vary widely with different operators and units.

Comparing the boiler hp. required for the different systems it is noticed that the closed wet process takes about three times as much steam as the dry at 216 deg. On the other hand, the former is capable of twice the capacity of the latter, so that the proportion of steam per can used is as 3 is to 2.

Efforts have been made to increase the capacity of process kettles by agitating the cans during cooking, machines for this purpose being styled "continuous cookers."

There seems to be ample field for enlightenment by experiment in the case of process kettles. Among the questions to be answered are: What are the times necessary to elevate the temperature of the center of a can under the open or closed systems, and how much difference is made by circulating water instead of steam upon the time? What effect has venting the kettle different amounts? What effect has agitating the cans? If such venting of the kettles has any favorable effect, how may the steam thus lost be recovered? How does the temperature of the cans at various parts of the kettle vary? Of what value are automatic regulators to steam economy?

POSSIBILITIES OF IMPROVING PERFORMANCE OF PLANT

Referring to Fig. 8, the possibilities of bettering the performance indicated by Fig 1 are shown. The consumption of the scalder is reduced from 25 to 20 boiler hp. by careful supervision of its performance. The efficiency of the jacketed kettle is improved by means of the return trap which passes back to the boiler 4½ boiler hp., thereby eliminating all possibility of waste in steam through the drain. The exhaust box is increased in efficiency to 50 per cent, and very probably much better than this can be secured with the more modern forms of exhaust box, the loss then largely being due to radiation. By using the dry process at 216 deg. the process kettle loses heat only to radiation in amount equal to about 5 boiler hp. and through condensate from the drain equal to about 6½ boiler hp., the loss through the vent with automatic regulation being negligible. It is questionable how the 6½ boiler

TABLE 2 COMPARISON OF HEATING-SURFACE REQUIREMENTS OF KETTLES AND COILS

Capacity of kettle, gal.	100	300	500	600 (tank with coil)
Heating surface per gal. of contents, sq. ft.	0.10	0.08	0.06	0.083

TABLE 3 AMOUNT OF HEAT (B.T.U.) REQUIRED FOR PROCESSING IN ONE KETTLE 40 IN. IN DIAM. BY 72 IN. DEEP

	½-hr. closed process at 240 deg. fahr.		1-hr. open process	
	Dry	Wet	Dry, 216 deg.	Wet, 212 deg.
To cans, from 120 deg.	198,000	198,000	158,000	152,000
To water, from 212 deg.	0	28,000	0	0 (?)
To metal, from 212 deg.	3,300	3,300	500	0
To vent on top	0+	17,500	0+	35,000+
Radiation	9,000	9,000	15,300	14,800
Overflow, or drain	38,000	46,000	26,000	29,300
Total B.t.u.	248,300	301,800	199,800	231,100
Boiler hp.	14.8	18.1	6.00	6.90

hp. escaping from the drain may be utilized. It might be returned to the boiler as feed if provision were made to eliminate impurities. An exhaust-steam feedwater heater is added, by means of which 26 boiler hp. is recovered, but as the exhaust steam is in excess of the requirements for preheating the feedwater, some of that available from the engine is lost through the vent. It is very possible that this excess of steam should be recovered in one of the steam-using units; for example, if a process kettle were designed with sufficiently large steam pipes and openings, exhaust steam could be used in it, or this steam could be used in a vacuum pan. There are a number of such possibilities.

GENERAL CONSIDERATIONS

Having now taken up in more or less detail the various familiar steam-using units in the canning factory, the writer would conclude with a few remarks of general application. Economy in steam means three things: increasing efficiency of units, eliminating all avoidable wastes, and utilizing all other wastes of heat as by-products. The first two can only be accomplished through measurement—it is necessary to know *how much steam* is used and wasted. The packing house should be properly equipped with measuring instruments for this purpose. The familiar and little appreciated pressure gage is almost a stranger in the packing house, and yet a judicious use of this instrument will disclose much valuable information as to how steam is being used or abused. To find

out how low the steam pressure is on some units whose inefficiency or lack of capacity has been ascribed to other causes and inspired futile remedies, will open the eyes of the superintendent. Next, when we eliminate wastes, we must eliminate *all wastes*, and not tolerate any just because we have been accustomed to seeing them and know that they are difficult to avoid. Wherever steam shows in the atmosphere it represents a waste, whether the steam comes from the jacket of a kettle, the vent of a process retort, the flue from an exhaust box or heater or scalder, or from any cause whatsoever. We have no right to shoot steam into the atmosphere, even if it is exhaust steam. We have no right to *radiate* heat to the atmosphere which might be saved by non-heat-conducting protection, and such wastes, it is necessary to say, are wantonly committed in the packing house. No steam-using units the writer has seen in such houses make the slightest provision against loss of heat by radiation. This is not only a waste of coal but a waste of human energy, since the operators cannot work efficiently in the torrid heat usually prevailing and aggravated by radiation from steam-using units. The packer objects on the ground of expense, but he should remember that each square foot of surface with steam behind it radiates to the atmosphere in ten hours an amount of heat requiring the burning of 1 lb. of present-day coal, and then, upon calculating what this aggregates to, will he realize that it is not a question of the expense of installing pipe coverings and other similar devices, but the expense of not doing so.

Finally, the question of how to utilize by-product heat requires careful study. In each factory the problem may be different, and in each it may be a separate case of proportioning the units to fit into each other. Feedwater heaters, traps, low-pressure heaters—all should be considered. Even the water used for cooling the cans, which carries away all of the useful heat transmitted, as previously defined, may be made to render up some of the heat it has removed.

AN INVESTIGATION OF THE FUEL PROBLEM IN THE MIDDLE WEST

By A. A. POTTER, MANHATTAN, KAN.

Member of the Society

THE cost of producing power has increased in the various power plants of the Middle West from 15 to 60 per cent during the winter of 1917-1918. The Detroit Edison Company report that for 1917 the total operating expenses were 35 to 40 per cent greater than in 1916. The Quincy (Ill.) Gas, Electric and Heating Company, states that the increase has been 40 per cent. The cost of production in the Sioux City (Iowa) Gas and Electric Company has been increased by 60 per cent.

The increased cost of producing power has been due to:

a The increase cost of fuel
b The necessity of burning fuels of different grades with equipment suitable for one particular grade
c The greater amount of ash and other non-combustible matter
d The increased cost of labor and the poorer quality of labor available
e The increased cost of repairs, supplies and new equipment.

For presentation at the Spring Meeting, Worcester, Mass., June 4 to 7, 1918, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here presented in abstract form, and advance copies of the paper may be obtained by members gratis upon application. All papers are subject to revision.

INCREASE IN COST OF FUEL

The Commonwealth Edison Company, of Chicago, Ill., report the cost of coal per ton, for January 1916, 1917 and 1918 as $1.78, $2.72 and $3.14, respectively. A large power plant in Indiana paid for coal an average of $3.60 per ton during the winter of 1917-1918, as compared with $1.66 during the winter of 1915-1916. A large power plant in Omaha, Neb., paid for fuel during the winter of 1917-1918 at an average rate of $4.45 per ton as compared with $2.85 in normal times. In Kansas power plants the cost of fuel has increased about 70 per cent as compared with normal years. The Jackson Light and Power Company, of Jackson, Miss., report an increase in the price of coal from $2.12 to $4.48.

GRADES OF FUEL USED

The majority of the power plants in the Middle West burned any grade of fuel they could secure and were forced in most cases to go to the open market for their supplies. Plants using bituminous screenings, slack and mill run were forced to burn mine run and even screened nut and lump coal. One large power company of Indiana, which ordinarily uses fourth-vein Indiana screenings, used during the winter of 1917-1918 only 40 per cent screenings and 60 per cent mine-run and lump coal. The larger sizes were purchased, partly on account of the difficulty experienced in securing any definite or uniform grade. The increased attention to coal storage was also responsible for the use of the larger sizes, as fine coal is more liable to danger from fire on account of spontaneous combustion. The use of lump coal necessitated in some plants additional expenditures for crushing before the fuel could be used with certain types of stokers.

Several plants in Illinois used coke breeze. Several plants in northern Louisiana and in the other southern parts of the Central West used wood and wood waste to a limited extent. In North Dakota greater use was made of lignite slack.

Some efforts were made in several states to use fuel oil in place of coal, but it was found more expensive than coal and in the majority of cases, more difficult to secure on account of the shortage of tank cars. In Kansas coal and oil were equally difficult to secure, except in the southeastern portion of the state where oil and natural gas are used exclusively in power plants. In Oklahoma natural gas is used ordinarily in the power plants at Oklahoma City, El Reno, Muskogee, Enid, Tulsa and other cities and towns. The power plants located near natural-gas fields experienced a great shortage of gas during the past winter and had to use fuel oil. In some plants this change meant an increase in operating costs of several hundred per cent. In the largest portion of Texas, lignite and bituminous slack were cheaper for power-plant use than fuel oil. Substitutions for coal were found impractical in most cases.

Suggestions have been made by power-plant engineers that the Fuel Administration should segregate the supplies from the different mines in such a manner that individual plants would get their supply of uniform grade. Where several hundred tons of coal of different grades are mixed and stored in overhead bunkers, it is impossible for stoker operators to adjust their firing conditions as to feed and draft to suit the fuel served. With uniform grades of fuel, operating conditions can be adjusted for best efficiency.

In several cases the fuel scarcity and high cost resulted in the greater use of coal near the producing point, but in most cases it was a question of keeping the plants going, irrespective of the price of fuel.

The fuel situation in the power plants of Iowa, Kansas, South Dakota, Texas and Oklahoma was not as serious as in the more populous states of the Middle West. Many of the smaller power plants either had considerable fuel in storage or reduced their load. The majority of the plants in the Middle West were affected more by the quality than by the scarcity of fuel.

Impurities in Coal

One large plant in Illinois reports that the coal used during the winter of 1917-1918 contained 16 per cent ash as compared with 9 per cent in former years. Several of the power plants in Minnesota reported 25 to 35 per cent ash and slate in coal during the winter of 1917-1918. The plants of Louisiana had to use coal which contained in many cases 30 per cent ash, as compared with an ash content of 5 to 10 per cent in former years. An engineer in a large power plant at St. Louis, Mo., stated that the cost of producing power in that particular plant has increased 51 per cent, 40 per cent being due to the increased cost of fuel and 11 per cent to the increased non-combustible impurities. In general, the ash content in the fuel used during 1917-1918 was at least 5 per cent greater than in former years on account of the faulty methods at the mines. Power-plant engineers feel that the high ash content is greatly responsible for the fuel shortage and for the increased operating costs. In ordinary times fuel containing more than 30 per cent ash would be condemned for use in boiler-room furnaces.

Cost of Labor

The cost of common labor has increased in the various parts of the Middle West from 25 to 100 per cent. Operators and firemen in power plants are receiving more pay, but in rare cases is the increase as great as 25 per cent when compared with normal times. The cost of manufacturing power has probably been more affected by the poor quality of power-plant operators and labor available than by the increased cost of such labor.

Effect Upon Isolated Plants

In a few cases the increased operating expenses and the scarcity of fuel had a distinct tendency to eliminate isolated plants and to transfer the load to central stations. This was especially true where the rates of central stations are maintained constant by law. The large central stations in most cases, however, were not too vigorously soliciting business on account of the increased costs of fuel, labor, material, and new equipment. Some power-plant managers insist on a coal-and-labor-cost clause in connection with contracts for power. Public utilities complain about the difficulties which they are experiencing in financing improvements.

Many power companies are more concerned on account of insufficient plant capacity than because of the increased cost of fuel. Improvements and extensions in equipment are affected by the high cost of money, by the high prices of materials and equipment and by the difficulty of securing deliveries of materials and equipment purchased. A manager of a large central station in Indiana states that they are three years behind in expansion, development and replacement.

Efforts for Better Fuel Economy

The fuel situation during the past winter has resulted in greater efforts for fuel economy. This is particularly noticeable in the small power plants of the less populous portions of the Middle West. The high cost of new power-plant equipment has some tendency to delay improvements, but it is remarkable to see power plants in towns of 2000 inhabitants, or even smaller, discarding an inefficient old steam prime mover and paying at the rate of $200 per kilowatt capacity for new units, in order to produce fuel economy. The use of draft gages and of other measuring instruments is increasing in the boiler room, greater attention is given to the utilization of exhaust steam in non-condensing plants, more pipe covering is used, greater attention is being given to boiler settings and furnaces, heating surfaces are kept cleaner, and definite efforts are being exerted for the more economical utilization of fuel in the power plant.

Work of the Fuel Administrators

The work of the Fuel Administration Boards of Iowa, of Louisiana and of Illinois, is particularly creditable. The fuel-conservation campaign in Iowa consists of:

a Inspection of boiler rooms and heating plants, with recommendations as to improvement in equipment and operation, and instruction of firemen in proper firing methods

b Talks to groups of engineers and firemen on combustion and firing methods

c Talks to general audiences on the economical use of fuel in the home, and on firing house furnaces; and

d Dissemination of information on burning soft coal in house furnaces. Inspections of house-heating plants were made to a very limited extent.

Iowa State College at Ames furnished seven engineers to carry on this work, each of whom spent during the past winter from two to twelve weeks making inspections and giving talks and demonstrations. Their services were available to any city or town in the state without charge except for traveling and hotel expenses.

Prof. D. C. Faber of the Iowa State College, who is the consulting engineer for the Federal Fuel Administration for Iowa, gives the following in his recent report:

> Thirty-four cities and towns asked for this service, including practically all of the larger cities of the state. 1354 plants were inspected, and 80 talks given to a total of 7330 people.
>
> The boiler-plant inspections were made to point out defects in equipment and operation, and to give the firemen proper instructions in firing methods. The inspectors were equipped with draft gages, CO_2 recorders, and thermometers for measuring flue-gas temperatures. The inspections varied from casual inspections to complete investigations of combustion conditions, as circumstances required. It is not possible to enumerate the defects found by the inspectors, but a few of the commonly found faults were: Leaky boiler settings; uncovered steam pipes; failure to remove soot at frequent intervals; failure to regulate fire by use of damper in uptake; fire too thick; and firing too large a quantity of coal at one time.
>
> In the talks to engineers and firemen, combustion, hand firing methods and boiler-room losses were explained. These talks were accompanied by lantern slides, charts and demonstrations.

In Louisiana an extensive campaign for fuel conservation has been undertaken under Leo S. Weil, advisory engineer for the Federal Fuel Administration for Louisiana. Mr. Weil gave a complete description of his work in *Power*, Vol. 47, No. 5. Efforts were made to have other fuels substituted for coal, but these were found impractical in most cases. The fuel consumption was decreased by shutting down some of the ice plants which operated during the winter at about one-third of their normal capacity, and the remainder of the ice plants were run at nearly normal capacity, supplying ice to those which were shut down. The attention of power-plant owners

and of operators was called to the necessity of reducing waste of coal and to the desirability of coöperation on the part of both owners and operators. Suggestions concerning reduction of coal waste were sent out to power-plant operators. Mr. Weil reports very gratifying results due to the above efforts.

The Conservation Committee of the Fuel Administration of Illinois, with Prof. H. H. Stoek of the University of Illinois as chairman, is carrying on very constructive work among the power plants of that state in the interest of fuel economy. Those in charge of power plants are being urged to go over their equipment and to make necessary improvements. The Conservation Committee has also the coöperation of the factory inspectors of Illinois, who are bringing the matter of economy to the attention of the owners and operators of plants inspected by them.

Conclusions

The power plants of the Middle West are convinced that future emergencies can be averted by more adequate fuel storage, by greater attention to fuel economy, and by the more careful regulation on the part of the Government of the quality of fuel leaving the mines and of the fuel-transportation facilities.

Several state fuel administrators are expecting to start campaigns urging the early purchase of fuel for domestic use, and greater storage of coal by power plants during the summer. The larger power plants are expecting to store greater amounts of coal than usual. Some plants expect to provide storage capacity sufficient for 30 days; many of the smaller plants expect to put in larger storage capacity. Considerable difficulty is being experienced in storing many of the middle-western bituminous coals on account of spontaneous combustion. Storage under water will be used to a considerable extent. The Nebraska Power Company, of Omaha, which uses 250 to 300 tons of coal per day, constructed two subaqueous coal storage pits of a total capacity of 8000 tons and at a cost of about $120,000. The Commonwealth Edison Company, of Chicago, devotes about 100 acres of high-priced land to coal storage. On this land are nearly ten miles of railroad tracks and other improvements, in addition to locomotives and locomotive cranes. Mr. W. L. Abbott, chief operating engineer of the Commonwealth Edison Company, states that in addition to the above investment in storage facilities there is the great expense of storing upward of a million dollars' worth of coal and carrying much of it year after year, but that the outlay and expense are warrantable from a business point of view.

In the case of power plants using natural gas, a gas-storage-tank capacity sufficient for a 10-day period is considered practical. Such a storage capacity will take care of gas shortage during extremely cold weather.

More attention will be paid in the future to the proper furnace design for high-volatile bituminous coals. The combustion chambers of the furnaces in the majority of the smaller power plants are not large enough for the air to mix with the gases given off from the fuel bed and before such gases come in contact with the comparatively cool heating surfaces of the boiler.

Some attention should be given to the use of peat in certain parts of Michigan, Minnesota and Wisconsin for domestic use and possibly also for power generation. With the increasing scarcity and higher cost of coal and oil, low-grade fuels must be given greater consideration in connection with the generation of power.

The fuel administrators of the various states should be encouraged to secure engineering assistance, particularly in connection with the campaigns for economy in the smaller power plants. Much fuel can be saved if the operators of the small power plants can be carefully instructed with reference to the overhauling of equipment, the avoidance of air infiltration through settings, proper firing methods, correct thickness of fuel bed and other operating details which lead to the economical utilization of fuel. The institution of campaigns for fuel conservation, such as have been undertaken in Louisiana and in Iowa, will result in greater fuel economy. Such campaigns are absolutely necessary in the less populous sections of the Middle West, where the majority of the power plants are small and are operated by poorly trained attendants.

E. G. Bailey, Mem.Am.Soc.M.E., advocated recently that the price of coal be regulated by the Government according to the quality of the fuel produced, in order to give the coal operator a real incentive to clean his coal as he should. He states that—

> The base price for standard quality of coal should be established by the Government as at present, with possibly different base prices and different quality standards for the several districts, taking into account the character of coal, height of seam and other mining conditions; but the main thing to strive for is to obtain the highest quality of coal and the most concentrated form of heat units in order to tide us over the coming year, which is going to be much more critical than that just past, unless some radical step is taken to apply a remedy for the basic cause of the present situation.

The United States Fuel Administration has announced that, beginning March 11, 1918, an inspection system will be effective to insure improvement in the quality of bituminous coal leaving the mines. Coal containing a high percentage of impurities will be condemned or will be sold at 50 cents per ton less than the fixed Government price for that coal. There is no definite system recommended upon which the inspector may base his conclusions as to the quality of the coal. In ordinary times the operators are forced by competition to produce a low-ash coal. It is possible that the Government may be able to improve the quality of the coal leaving the mines by enlisting all mine officials and employees in some form of industrial army for coal production. Otherwise, some definite plan of fixing prices for definite quality standards should be worked out.

A detailed study of coal-car movements in the Middle West during the past four years discloses the fact that the average time required to move cars is extremely long. In most cases cars carrying coal will average less than 20 miles per day. When to this time is added the time required for empty cars to return to the mines, it is evident that the coal tonnage handled per car per year is very limited and very much smaller than reasonably efficient operation should produce. This delay is due partly to the practice by railroads of throwing cars on sidings and into yards with unnecessary switching, instead of delivering them to their destination in one or two hauls. Pooling of engines, cars and routes can be made to substantially relieve this situation. Another relief can come by so routing coal as to avoid, as far as possible, the congested terminals at the larger cities.

To avoid the recurrence of the conditions of last winter, the power plant men will have to coöperate with the Government by providing adequate coal-storage facilities, by unloading fuel without delay after it reaches its destination, and by giving careful attention to power-plant economy. The Government will have to insist upon reasonable cleanliness of coal leaving the mines, and should give more attention to the improvement in the railroad equipment and in the methods of transporting coal from the mines to the consumer.

THE PUBLIC INTEREST AS THE BED ROCK OF PROFESSIONAL PRACTICE

A Discussion of the Objects of Engineering Societies and Their Obligations to the Public

By MORRIS LLEWELLYN COOKE, PHILADELPHIA, PA.

Member of the Society

THE members of our Society individually are doing everything in their power to help to win the war. To this end we dedicate personal convenience, financial interest, and life itself. A study of the program of this and other recent meetings of the Society indicates that collectively our aim is the same. One has but to read the technical engineering journals to realize that perhaps no other profession is so profoundly affecting the actual conduct and progress of the war as is our own. Without doubt, engineers as a class are making every possible effort, and at every possible sacrifice, to make Liberty triumph in the present struggle. In other words, there is in our conduct the clearest recognition of the paramount obligation which we owe to the Nation, and, in the last analysis, to humanity. In view of this attitude taken spontaneously in time of war, it is curious to note that our public responsibilities are almost ignored in the codes of ethics of our organized associations of engineers. Drafted as they have been to control our conduct in times of peace, these canons of professional practice carry almost no reference to the public interest as a controlling, much less as a paramount, obligation of the individual engineer, of engineering societies, and of the profession as a whole.

This is a time of stock taking and of a critical examination of the orders under which society and its constituent elements are operated. Within the church, among labor organizations, in government, in the educational field, and in the professions,—everywhere, in fact,—we find the same searching inquiry as to aims and methods. Hence, there can be no better time for a review of the codes of ethics designed to regulate the professional practice of engineers. The object of this paper is to determine what has been, and apparently continues to be, the attitude of engineering organizations toward society as expressed in our rules of conduct. It is further sought to develop the engineer's concept of his public relationships and responsibilities as contrasted with such relatively minor obligations as those to the profession of engineering, to a client, to fellow-engineers, and to himself.

The oldest, the largest and perhaps the most representative society of American engineers, the American Society of Civil Engineers, for instance, makes absolutely no mention in its Code of Ethics of any such public responsibility. The Code in full is as follows:

> It shall be considered unprofessional and inconsistent with honorable and dignified bearing for any member of the American Society of Civil Engineers:
>
> To act for his clients in professional matters otherwise than as a faithful agent or trustee, or to accept any remuneration other than his stated charges for services rendered his clients.
>
> To attempt to injure falsely or maliciously, directly or indirectly, the professional reputation, prospects, or business, of another Engineer. To attempt to supplant another Engineer after definite steps have been taken toward his employment. To compete with another Engineer for employment on the basis of professional charges, by reducing his usual charges and in this manner attempting to underbid after being informed of the charges named by another. To review the work of another Engineer for the same client, except with the knowledge or consent of such Engineer, or unless the connection of such Engineer with the work has been terminated.
>
> To advertise in self-laudatory language, or in any other manner derogatory to the dignity of the profession.

The first of these three sections refers exclusively to the engineer's relationship to the client, the second to his relationship to fellow-engineers, and the last simply deprecates advertising.

The code of the A. S. M. E. contains a section devoted to The Engineer's Relation to the Public, but it includes no recognition of the fundamental character of the obligation of the engineer to the public. Even the engineer's responsibility "to extend the general knowledge of engineering" is quite incidental. The major import of these injunctions has to do with a negative phase of the subject, i. e., the holding back from the public of inaccurate information or of too narrow statements with regard to engineering subjects. The really significant sentence in our code reads:

> The Engineer should consider the protection of a client's or employer's interests *his first obligation* [italics mine], and therefore should avoid every act contrary to this duty.

This sentence is fairly typical of what appears to be the keynote not only of this, but of every engineering code. These codes have apparently been drawn to hold up a high standard of personal integrity in relations with the client and to protect one engineer against another.

The omission of any reference to the public interest in the codes of professional practice of engineering organizations would not be so noticeable were it not for the fact that other associations of professional men have been at very considerable pains not only to express the obligation, but to insist on its paramount importance, and to phrase it in terms of lofty idealism.

The architects, whose work in many respects is quite comparable to that of the engineer, have been emphatic and successful in their efforts to govern their professional conduct along ethical lines. They have further made the effort to stress the public character of the profession, and to reward those who have made distinct contributions in the public service.

Perhaps the most conclusive statement in this matter is that which appears in the Code of the American Bar Association under the head, The Lawyer's Duty in Its Last Analysis:

> No client, corporate or individual, however powerful, nor any cause, civil or political, however important, is entitled to receive, nor should any lawyer render, any service or advice involving disloyalty to the law whose ministers we are, or disrespect of the judicial office, which we are bound to uphold, or corruption of any person or persons exercising a public office or private trust, or deception or betrayal of the public. When rendering any such improper service or advice, the lawyer invites and merits stern and just condemnation. Correspondingly, he advances the honor of his profession and the best interests of his client when he renders service or gives advice tending to impress upon the client and his undertaking exact compliance with the strictest principles of moral law. He must also observe and advise his client to observe the statute law, though until a statute shall have been construed and interpreted by competent adjudication, he is free and is entitled to advise as to its validity and as to what he conscientiously believes to be its just meaning and extent. But above all, a lawyer will find his highest honor in a deserved reputation for fidelity to private trust and to public duty, as an honest man and as a patriotic and loyal citizen.

Engineers need not be told that an axiom is undebatable. Surely no one will hold that the public interest is not funda-

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mental to all professional ethics and practices. It is not even necessary to vote on the proposition. The simple enunciation of the statement makes it so obvious that further action is in a way unnecessary. On the other hand, one must necessarily question codes of ethics and canons of professional practice which have been drafted without the clearest possible recognition of the fact that such rules and regulations must be interpreted in the light of public interest.

In much of the vital engineering of the time the determinations are inextricably interwoven with questions of public policy. In fact, enlightened public engineering is in many directions the insistent need of the hour. If the established engineering agencies fail to respond both efficiently and disinterestedly to this call for service, others will inevitably be created more in the spirit of our great time.

Practically all the questions affecting professional practice among engineers that have been raised during the last few years would have settled themselves had this one standard of the public interest been held to be fully operative while at the same time the interest of the profession as a whole, the relations of the engineer to his client and those of one engineer to another engineer, were being safeguarded as far as consistent with the public interest.

We frequently hear it said both by engineers and by laymen that this is the day of the engineer, or rather that the day is just dawning when society must become increasingly dependent upon engineering. Can this day really arrive so long as the rules and regulations for our professional conduct are so largely taken up with rather crude and in many cases debatable injunctions, which have more to do with what might be called "keeping the peace" than with our immeasurably more important task of providing such an enlightened leadership in the present as will make our dreams of the future come true?

My own feeling is that every code now in use by engineers in this country and abroad should be entirely rewritten on much broader lines and in a more inspiring key. It is useless to undertake such revision unless we have determined that we shall open every such code with the clearest possible enunciation of the principle that no considerations of professional or other special interest shall weigh for one moment against the interests of the nations and of humanity itself.

STRESSES IN MACHINES WHEN STARTING OR STOPPING

Method for Their Determination, Taking Account of Inertia and Elasticity

By F. HYMANS, NEW YORK, N. Y.

Member of the Society

A CYCLE of operation of a machine can be divided in three more or less distinct periods, namely, the start, the run at constant speed, and the stop.

The calculation of machine parts follows at present one of two methods. The first assumes a state of equilibrium, which permits the application of the known processes of statics to determine the forces acting on each machine part. The state of equilibrium, however, exists only when the machine runs at constant speed or is at rest.

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In the second method all of the machine parts are considered to be rigid. The calculations are based on the external forces as they exist during stop or start, from which the forces acting on each machine part are determined by means of the dynamics of rigid bodies.

Neither of these methods leads to even approximately correct results. The first may be dismissed altogether, since no consideration whatsoever is given to the quite different phenomena occurring at start or stop. In the second such a consideration is attempted, but is based on entirely wrong premises. For, if correct, the forces acting on the machine parts merely depend on their inertia and on the magnitude of the external forces. From experience, however, it is known that the forces acting on a machine part do not only depend on the above

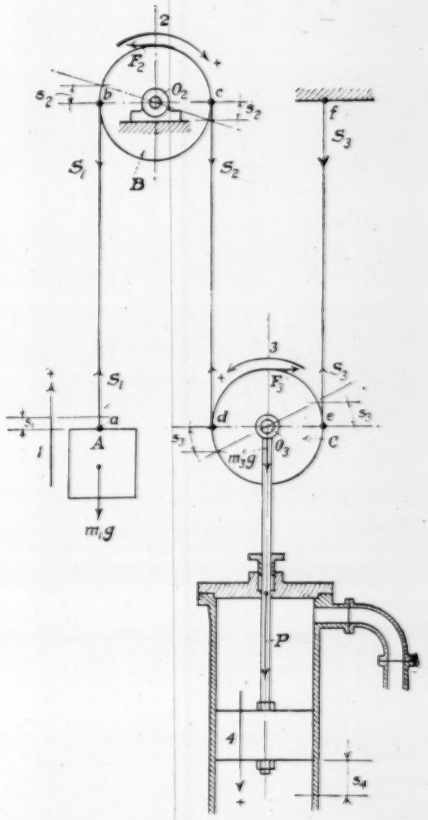

FIG. 1 DIAGRAM OF HYDRAULIC MACHINE

two factors, but, for example, also on the *nature* of the external forces. A feeble periodic force of the proper frequency, for instance, may cause the breakdown of a machine where a constant force of several hundred times its magnitude would be easily withstood. It is plain, therefore, that this method neglects the consideration of some property through which in the resulting formulæ the influence of the nature of the external forces vanishes. This property is the elasticity of the machine parts.

It is the object of this paper to present a method whereby the forces acting on the machine parts during start or stop may be determined with a degree of accuracy more than sufficient for technical purposes. While the method is explained in sufficiently general terms for ready application to any machine, it is more specifically applied to the determination of the motion and rope tensions during the starting of the hydraulic machine shown diagrammatically in Fig. 1.

As the figure shows, the machine consists of a vertical cylinder with a piston, adapted to lift the load A through the in-

termediary of a piston rod, a traveling sheave C, a stationary sheave B, and the ropes ab, cd and ef. The force P, acting on the piston and causing the motion of the machine, will be called the motive force, in distinction to all other external forces, such as the weight of load and machine parts, and the frictional forces.

According to the foregoing, it is necessary to consider not only the inertia of the machine parts, but also their elasticity. Strictly speaking, all of the machine parts are elastic. Fortunately, however, there are always a few which have elasticity to such a predominating degree that other parts in comparison with them may be considered to be rigid. Thus any machine may be approximated by a system of parts, of which some have elasticity and others inertia only.

In the machine of Fig. 1, for example, it is at once evident

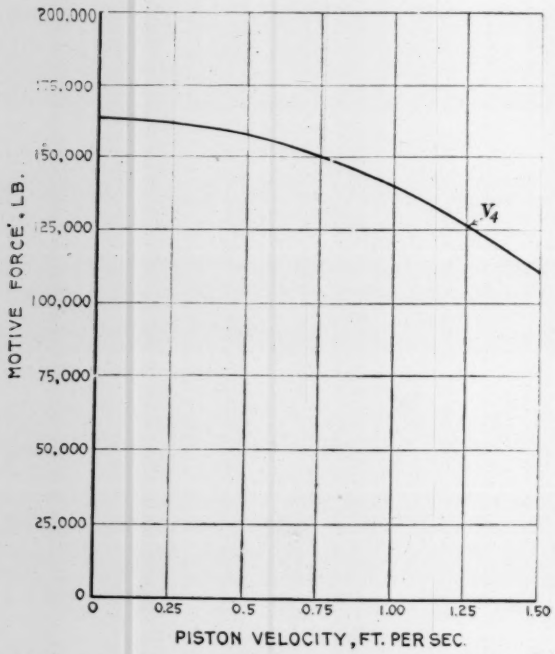

FIG. 2 MOTOR CHARACTERISTICS (MOTIVE FORCE AND PISTON VELOCITY)

that the ropes ab, cd and ef will be considered as the only elastic members. Their mass is very small and may be neglected. The remainder of the machine parts, that is, the load A, sheaves B and C, the piston and piston rod, will be considered rigid.

The author's method is based on the general energy equation of the machine, from which he derives all of the equations required in the further calculations. According to dynamics, this equation states that the gain in kinetic energy plus the gain in potential energy equals the work done by the external forces.

To derive the energy equation of the machine certain displacements are assigned to the rigid machine parts, such as s_1, the linear displacement of the load A; s_2 and s_3, the circumferential displacements of points b and c of sheave B, and of points c and d of sheave C; and s_4, the linear displacement of the piston and the parts rigidly connected thereto. Since the velocity of the rigid parts is the first time derivative of their displacements, it is quite simple to derive for each of them the expression of the kinetic energy. The kinetic energy of the machine then is the sum of the kinetic energies of its constituent parts.

The elastic machine parts—here the ropes ab, cd and ef—are the seat of the potential energy of the machine. By virtue of their elasticity they are capable of sustaining deformations, and so long as they are stressed below the elastic limit there is stored in them an amount of energy equal to the energy that produced the deformation. This energy is called the potential energy.

Considering now the rope ab, it is evident that if the end b has moved through the distance s_2, and the end a through the distance s_1, the rope has suffered an elongation equal to $s_2 - s_1$. Knowing further the elongation which a tension of 1 lb. will cause in the rope, it is merely necessary to apply the well-known laws of statics to determine the energy necessary to produce the deformation $s_2 - s_1$.

This process is also applied to ropes cd and ef, and the potential energy of the machine will be the sum of the potential energies of its constituent elastic parts. The derivation of the work done by the external forces needs hardly any elucidation.

From the foregoing it will be evident that, after having determined which of the parts shall be considered elastic and which rigid, the derivation of the general energy equation of the machine will not present any considerable difficulties. It will also be quite clear that the machine parts to be considered rigid are those wherein either the stress or the deformation, or both, are so small that the amount of potential energy stored in them is negligible. Further operation with the general energy equation is facilitated by the resolution of the absolute motion into two components, which the author calls rigid and relative motions. This is based on the following considerations.

The tension in rope ab (see Fig. 1) changes from instant to instant during the start of the machine. If the tension decreases, the rope contracts, causing points a and b to approach each other. Vice versa, if the tension increases they recede from each other. These varying elongations, however, are merely varying increments in the free length of the rope ab. It follows at once that the motion of points a and b, that is, the motion of the load A and of point b of sheave B, consists of two components.

One of these components is common to both, and is a motion wherein the linear distance between the points a and b is preserved and remains equal to the free length of the rope. The second component is superposed on the former, and corresponds to the varying elongations due to the rope's elasticity.

It will be seen that the component first named is the motion which would take place if the rope ab were non-extensible. In general, the motion of each machine part is the same as the motion which it would have if all of the machine parts were rigid, superposed by a motion relative thereto. It is this relative motion which is neglected if the calculations are based on the assumption of a state of equilibrium, or if all of the machine parts are assumed to be rigid.

The energy equations for the rigid and relative motions are easily derived from the general energy equation, and may be integrated separately. To prepare for the integration of the energy equation of the relative motion, the author makes use of the so-called theory of normal coördinates, which is explained at sufficient length in the paper for ready application to the problem in hand. By means of this theory the displacements s_1, s_2, etc., may be expressed as the sum of a number of normal displacements, each of these being the product of a normal constant into a normal coördinate. Of the normal constants and coördinates only a few general types need be determined.

Of the external forces acting on the machine, all are constant with the exception of the motive force P. Strictly speak-

ing, the frictional forces are also variable, and are really functions of the motion of the machine. On the other hand, the coefficient of friction depends on a number of factors which are only imperfectly known. In addition, the frictional forces are, as a rule, very small as compared with the other forces acting on the machine parts. There is therefore no advantage in introducing needless refinement, and it is sufficient to consider the frictional forces as constant.

If it were possible to express the motive force in an explicit function of the time, the above-mentioned integrations could be executed easily, either mathematically or graphically. For machines yet to be built this is impossible. However, there is available for the further calculations what is known under the name of the motor characteristics.

The motor in general will be that machine part which is the seat of the motive force, irrespective of the latter being

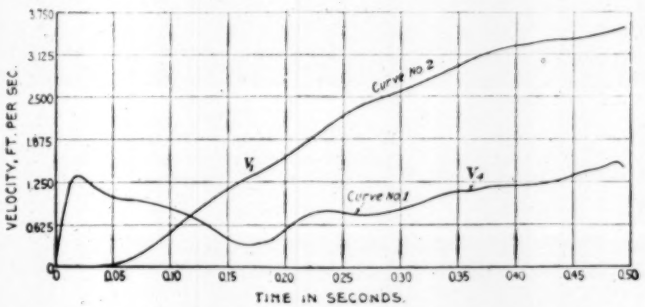

FIG. 3 ABSOLUTE VELOCITIES OF PISTON (CURVE NO. 1) AND OF LOAD (CURVE NO. 2)

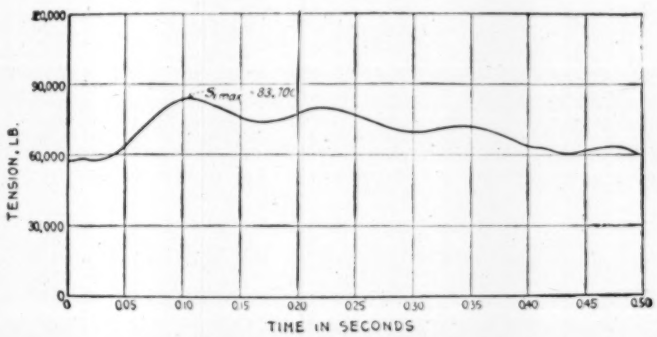

FIG. 4 TENSION S_1 IN ROPE *ab* OF FIG. 1

due to electric, hydraulic, steam or gas pressure. As is known, the force or torque exerted by these motors varies with the motor speed, although the manner in which these variations take place is frequently too complex to be adequately expressed in a mathematical formula. Fortunately, the latter is not necessary for the purpose in hand, since it is always possible from tests with the motor alone to derive a graph showing the variation of the motive force with the motor speed.

In the present case, the motor characteristics will be the performance of the piston alone when operating in the cylinder under the given conditions as to piping and water pressure. They are represented by Fig 2, which shows the net force P which the piston rod will exert at various piston speeds.

The calculations proceed by dividing the starting period into time intervals of so small duration that the motive force during any such interval may be considered constant, without that an appreciable error is committed.

For the first time interval, beginning with zero piston speed, it is found from Fig. 2 that the motive force P amounts to 163,000 lb. For the entire duration of this interval, taken at 0.005 seconds, the motive force is assumed to remain constant at 163,000 lb. Under these conditions the various displacements, rope tensions and piston speeds are determined. At the end of the first time interval the piston speed amounts to 0.578 ft. per sec., when from Fig. 2 it is at once found that a motive force of 155,200 lb. corresponds to that speed. For the second time interval the motive force is then assumed to be constant at 155,200 lb. and the calculations are repeated.

The results of the calculations are shown in the complete paper in various graphs, of which four are here given in Figs. 3, 4, 5 and 6.

Particularly instructive in regard to the phenomena occurring at the start is Fig. 3, in which curve No. 1 represents the velocity of the piston, and curve No. 2 the velocity of the load A. Owing to the small inertia of the piston masses, it

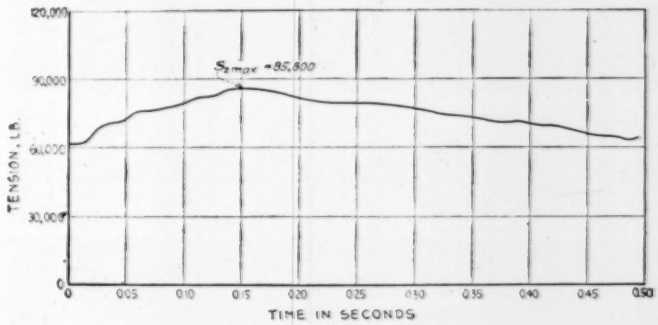

FIG. 5 TENSION S_2 IN ROPE *cd* OF FIG. 1

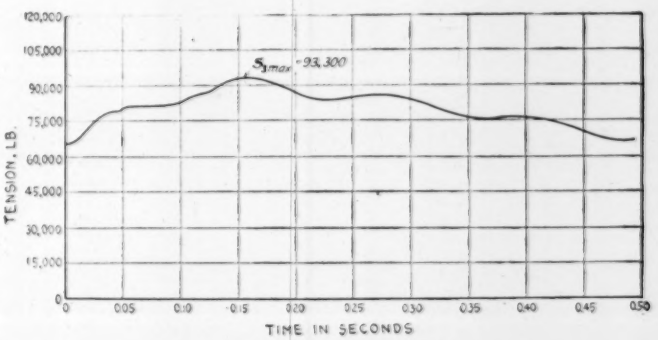

FIG. 6 TENSION S_3 IN ROPE *ef* OF FIG. 1

must of course be expected that at the application of the motive force the equilibrium of the piston will be violently disturbed, while the effect on the heavy load will be less severe. This is clearly reflected in Fig. 3, where the piston speed rises from zero to 1.35 ft. per sec. within about 0.02 sec., whereas the velocity of the load after a lapse of even 0.05 sec. amounts to only 0.03 ft. per sec. That such conditions, nevertheless, do not lead to heavy stresses in the ropes is due to the nature of the motive force. Large variations in the piston velocity cannot persist, since the motor characteristics are such that an increase in the motor speed corresponds at once to a drop in the motive force (see Fig. 2), and vice versa. The motive force, therefore, has the tendency to counteract large variations in the piston speed, as witnessed by the smoother course of curve No. 1, Fig. 3, after the first violent rise. If the ropes of the machine of Fig. 1 were non-extensible, or as soon as the machine was running at constant speed, there would be a 2:1 ratio between the motion of the load and that of the piston. Owing to the elasticity of the ropes, however, there is no

vestige of any such ratio during the start, as will be seen from an inspection of Fig. 3. After a lapse of 0.05 sec., for example, the ratio between velocities of load and of piston is as much as 1:35; after 0.117 sec. it is 1:1; after 0.3 sec. it is approximately 3:1.

The rope tensions as they vary with time are shown in Figs. 4, 5 and 6. In the state of equilibrium $S_1 = 58{,}000$ lb., $S_2 = 61{,}000$ lb., and $S_3 = 64{,}300$ lb. During the start, however, $S_{1\max.} = 83{,}700$ lb., $S_{2\max.} = 85{,}800$ lb., $S_{3\max.} = 93{,}300$ lb., exceeding the former by 44.2 per cent, 40.5 per cent, and 45 per cent, respectively. It will be seen that in the present case the forces S_1, S_2 and S_3 are not very considerably in excess of the values which they have as soon as the machine runs at constant speed. This is primarily due to the nature of the motive force, as already explained.

From the foregoing it follows that the stresses in a machine at starting or stopping depend on a number of factors, namely:

1 The inertia of the individual parts, in particular the inertia of the motor in respect to that of other parts. The heavier the motor mass, the less violent will its equilibrium be disturbed at the start and the smaller the resulting stresses

2 The position of the motor mass within the system. The effect of a locomotive, for example, placed at the head of a string of cars, will be quite different than when placed in the middle

3 The elasticity of the individual machine parts

4 The distribution of the elasticity throughout the system. If, for instance, the equilibrium of the motor is liable to be violently disturbed at the start, the stresses in the machine will be less if the motor is coupled to the remainder of the machine by very elastic members

5 The nature of the motive force. In the hydraulic machine of Fig. 1 the drop in the motive force is approximately proportional to the square of the piston speed. Had the motor characteristics been such that the drop in the motive force was only proportional with the piston speed, far larger stresses would have resulted.

THE ELASTIC INDENTATION OF STEEL BALLS UNDER PRESSURE

By C. A. BRIGGS, WASHINGTON, D. C.

Member of the Society

W. C. CHAPIN,[1] and H. G. HEIL[1]

Non-Members

IN the adjustment and standardization of precision apparatus at the Bureau of Standards incidental to the testing of munition gages, the subject of the effect of pressure on the dimensions of steel balls and length standards having rounded ends came up for consideration. After a preliminary study of the matter it was concluded that the distortion of the steel balls between the contacts, and the elastic compression of the portion of the rounded ends not directly in contact with the measuring surfaces, was very small, a conclusion that appeared inconsistent with some of the results that had been obtained in actual measurements. This directed attention from the main portion of the steel ball or rounded surface to the elastic indentation of the surfaces immediately in contact with each other. In order to settle the questions arising, experiments were undertaken, and the results obtained form the substance of this report.

These experiments, while limited in scope, were so successful in giving consistent results and data of apparently wider application than that originally intended, that it appears desirable to make a brief report summarizing and recording the information obtained. Owing to the fact that the effect of high pressure was of no immediate interest in reference to the problem in hand, and to the fact that to extend the investigation to greater pressures would have required time that was needed for other matters, low pressures only were employed.

The maximum pressure used on steel balls against glass plates was 20 lb., which was used on balls $^3/_4$ in. and 1 in. in diameter. On smaller balls the maximum pressure used was 10 lb. The results, therefore, do not represent conditions present when high pressures are used, such as occur in the Brinell hardness test of materials where the stresses are above the elastic limit; or pressures such that the indented area includes a solid angle large enough to invalidate the assumption frequently made when the angle is small that the sine and angle are equal. However, the results obtained do give accurate information of the effect of pressures on the measured diameters of spherical surfaces of steel or other materials which are employed in standardizing gages; and also appear to give information of practical value as to what occurs in ball bearings.

The experiment was performed by observing and measuring with a micrometer microscope the area of contact made by flat and spherical surfaces in contact with each other under varying pressures. This area of contact was viewed as the central spot in the Newton's ring system formed when a glass surface was in contact with a polished surface of steel or with another glass surface. The amount of indentation was obtained from the measured diameters by a very simple computation, easily derived, which it is not necessary to give at this time.

The different combinations of surfaces available for observation and use in the experiments were: a steel sphere pressing against a flat glass surface; a spherical glass surface pressing against a flat steel surface; and a spherical glass surface pressing against a flat glass surface.

From an examination of the results for each pair of surfaces in contact plotted on log paper, and from general reasoning based on the nature of the phenomena, a general equation was worked out for the purpose of correlating all of the results. It is not necessary for present purposes to expand this report by giving all of the various considerations which lead to the particular form assumed for this general equation—suffice it to state that after the constants of the general equation had been determined from the experimental data, the experimental values were reobtained by computations from the general equation, and the agreement between the computed and experimental values was very good. In fact, the agreement was so satisfactory that it was considered unnecessary to take additional data from the same material, as had been contemplated up to that time.

In the case of steel against steel it was of course not possible to observe the area of contact owing to the opaque nature of both contact surfaces, so that the values of steel against

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steel were obtained by the use of the general formula which had been found to fit all the various surfaces and materials used in the experiments.

It will be noted in the equations which follow that a quantity called the "indentation modulus" is used to express the elastic property which determines the indentation. It was originally intended to use Young's modulus as representing in a general way the elastic properties. However, on looking up the elastic constants of glass it was found that a problem of very similar nature had been worked out by Hertz from theoretical considerations which gave practically the same form of equation as was derived in the present experiments, in contact with cylindrical surfaces—such as are represented by many forms of ball and roller bearings in every-day use. It would be also of interest to extend the experiments already made by employing higher pressures.

The elastic coefficients for the materials used in the experiment of this report were obtained from tabular data. If, in the future, it becomes desirable to obtain information on the indentation of surfaces with great precision, experiments should be performed on materials that have had their properties carefully measured, so as to fix with exactitude the values of Young's modulus and Poisson's ratio for the particular steel and glass used in the experiment.

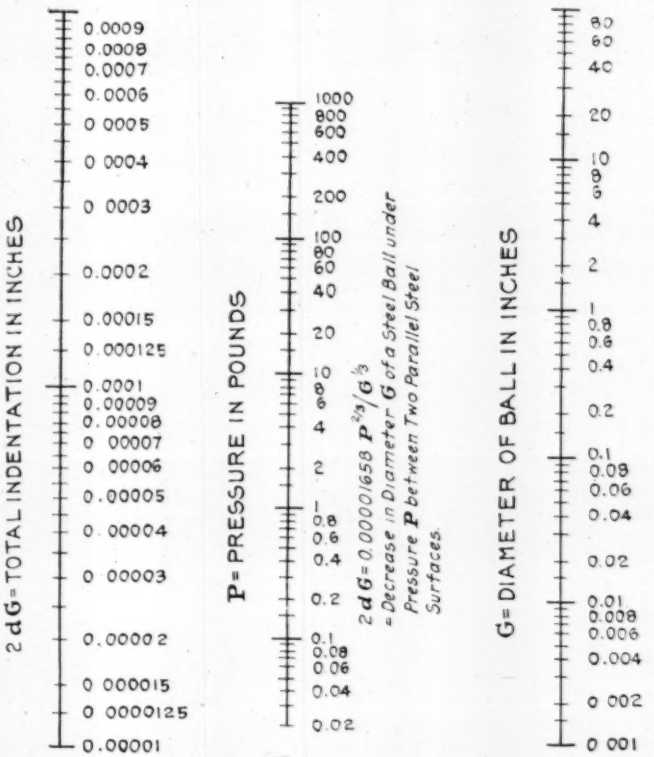
2 dG = TOTAL INDENTATION IN INCHES
P = PRESSURE IN POUNDS
2 dG = 0.0000/658 P^2/3/G^1/3
= Decrease in Diameter G of a Steel Ball under Pressure P between Two Parallel Steel Surfaces.
G = DIAMETER OF BALL IN INCHES

FIG. 1 CHART FOR DETERMINING THE INDENTATION OF STEEL BALLS

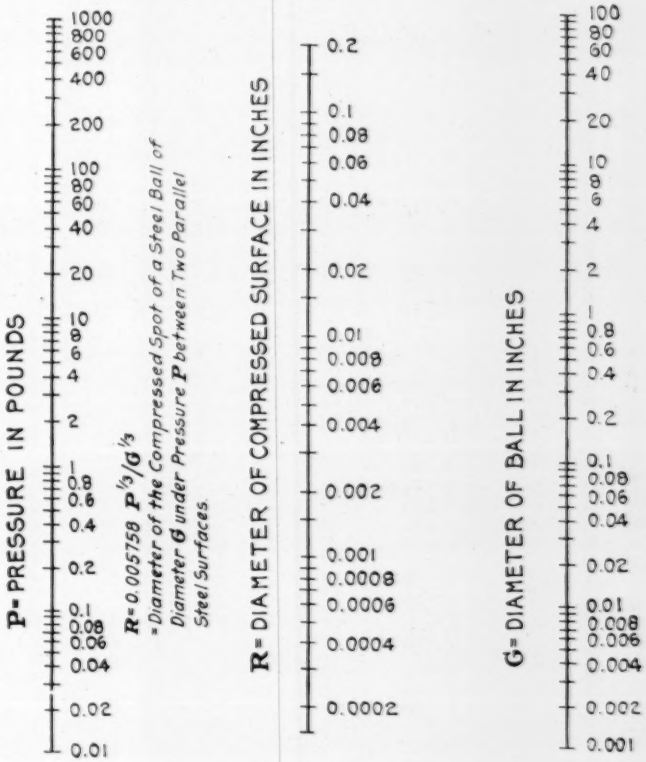
P = PRESSURE IN POUNDS
R = 0.005758 P^1/3/G^1/3
= Diameter of the Compressed Spot of a Steel Ball of Diameter G under Pressure P between Two Parallel Steel Surfaces.
R = DIAMETER OF COMPRESSED SURFACE IN INCHES
G = DIAMETER OF BALL IN INCHES

FIG. 2 CHART FOR DETERMINING THE DIAMETER OF THE INDENTED SPOT OF STEEL BALLS

and in which the elastic property effective in determining the indentation was found by Hertz to be a function of Young's modulus and Poisson's ratio, and which was called the indentation modulus.

A very interesting feature which can be noted on examining the results is that the indentation is not linear with the pressures but is proportional to the two-thirds power of the pressures. This is a fact of important interest in connection with the design of ball bearings, as it indicates what effects are produced on the distribution of the load by slight variations in the size of the balls in a bearing.

For steel against steel, which is the case of most general and important interest, the results are given in the form of computation charts, Figs. 1 to 3, by means of which numerical values can be obtained quickly for any particular case covered by the equations. (Three other charts, in which metric units are used, are given in the complete paper.)

In reference to future experiments, those which would appear to be of most practical interest are concerned with the determination of the elastic indentation of spherical surfaces

The results of the experiments are summarized in the eight equations which are given below.

General Equation for Indentation:

$$dG = 0.518\sqrt[3]{P^2[(G_1 + G_2)/G_1G_2]\,[(1/E'_1)+(1/E'_2)]^2} \quad [1]$$

where

dG = the mutual indentation between the surfaces in contact

P = the pressure acting between the two surfaces

G_1 and G_2 = the radii of curvature of the two surfaces

E'_1 and E'_2 = the indentation moduli of the surfaces G_1 and G_2.

The indentation modulus is given by the expression

$$E' = E/(1 - u^2) \quad [2]$$

where E = Young's modulus and u = Poisson's ratio. The constant 0.518 is the same for both metric and English units when either are used consistently throughout the formula.

Indentation of Steel Balls Between Flat Steel Surfaces. For metric units the indentation is given by the equation

$$2dG = 0.00210\sqrt[3]{P^2/G} \quad [3]$$

where $2dG$ is the indentation in millimeters from both sides of the ball. For English units the equation is

$$2dG = 0.0000166\sqrt[3]{P^2/G} \quad [4]$$

where $2dG$ is given in inches.

Diameter of Area of Contact Between the Surfaces, Steel Against Steel. For metric units—

$$R = 0.0647\sqrt[3]{PG} \quad [5]$$

where R is the diameter of the spot in millimeters. For English units—

$$R = 0.00576\sqrt[3]{PG} \quad [6]$$

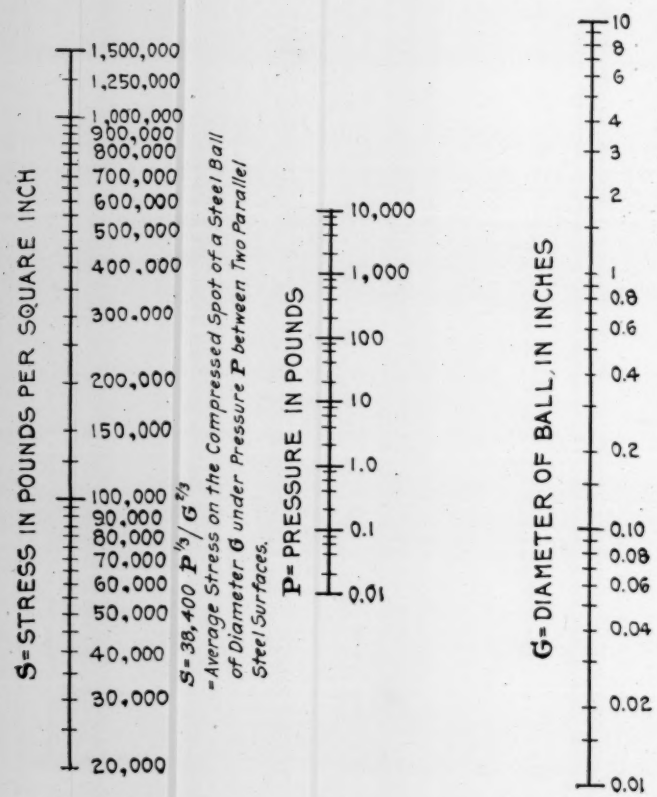

FIG. 3 CHART FOR DETERMINING THE PRESSURE PER UNIT AREA ON THE INDENTED SPOT OF STEEL BALLS

where R is given in inches. If the general equation is desired for R it can be derived easily from Equation [1].

Average Pressure Over the Area of Contact, for Steel Against Steel. For metric units—

$$S = 304\sqrt[3]{P/G^2} \quad [7]$$

where S is given in kilograms per square millimeter. For English units—

$$S = 38{,}400\sqrt[3]{P/G^2} \quad [8]$$

where S is given in pounds per square inch. If the general equation for S is desired it can likewise be developed from Equation [1].

Computation Charts. Means for graphically solving the preceding equations in English units are shown in the charts Figs. 1, 2 and 3. A straight line placed across any of the charts will strike readings on the vertical scales which are a solution of the corresponding equation. With these charts, when any two of the three quantities of the equation are given, these quantities will establish two points which determine a straight line, and the value of the third quantity will be given by the intersection of the straight line on the corresponding vertical scale.

ELECTRIC HEATING OF MOLDS

BY HAROLD E. WHITE, AMPERE, N. J.

Member of the Society

SYNTHETIC molding materials are being used on an increasingly extensive scale not only for parts of electrical machinery, but for many other articles of usefulness. It is the purpose of this paper to describe a novel method of applying heat to the molds in which such parts are formed, which the writer believes will be of general interest and of considerable utility under certain conditions.

The earliest example of such a material is perhaps hard rubber or vulcanite. More recent examples are the phenolic condensation products sold under various trade names. All of these materials are alike in that a moderate degree of heat causes them to soften sufficiently to take the form of the mold, while a higher degree of heat causes them to undergo chemical changes that harden them into a highly resistant condition.

Manufacture of parts made of this material on a small scale under the observation of the writer led to the development of the new method of production which is described. While it is not believed that this method can replace the methods used in factories which specialize on these materials, it would appear, nevertheless, that it can be used with success in almost any machine shop equipped with a hydraulic press, or even an arbor press if the articles are small, provided alternating current is available.

At first an attempt was made to use the standard method of production, which was to place the filled molds between two steam-heated plates attached respectively to the upper and lower platens of the hydraulic press. Live steam at about 110 lb. per sq. in. was admitted to these plates until the pieces were fully hardened. Then cold water was circulated through the same plates until the mold was cold, after which the mold was taken out and refilled for another piece.

Under these conditions production was slow and frequently interrupted altogether. The slowness of production was due to the fact that heat was not transmitted rapidly enough from the hot plates to the mold because the steam was often wet and the plates had a lower temperature than the boiler pressure would indicate. These difficulties were accentuated by the fact that most of the molds were long and slender, so that they had but a small part of their surface in contact with the hot plates and a large part of their surface in contact with the air. The heating and cooling of the fittings alternately carrying the steam and the cooling water resulted in frequent leaks, especially in the flexible piping, the use of which was necessitated by the movement of the upper platen of the press.

During one of these periods of interruption recourse was had to a method of electrical heating with such good results that the use of steam was abandoned altogether. In brief, the method consisted in magnetizing the molds with alternating current at 60 cycles. As these molds are always made of steel and generally hardened, they will heat up rapidly under these conditions, due to induced electric currents in the various parts of the molds, and also in some measure to hysteresis losses, especially in the hardened parts.

The method as at first used was simple in the extreme. The coil was made of 100 turns of No. 6 asbestos-covered wire, and when in operation its terminals were connected by a switch

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directly to the 220-volt supply line. With molds weighing 10 to 15 lb. a curing temperature could be reached, starting cold, in from 3 to 5 min. It should be understood that under the conditions of working the magnetizing coil remains quite cool.

The heat is developed in the interior, though mostly near the surface, of the molds. If the current is left on indefinitely a temperature destructive to the molding material results. This necessitates some way by which a definite result may be secured. Generally, it is sufficient to make trial pieces, noting the time of heating of each by a watch or clock. A good method of gaging the temperature of the molds is to observe the color of sulphur when melted in contact with the mold. A better material is a cane-sugar syrup with a little blue litmus, which clings to the hot molds and chars to a tobacco-brown when the temperature limit has been reached.

A study of the heating action in detail is interesting. Referring to Fig. 1, P' and P'' are the cast-iron platens of the press, M the matrix, and K' and K'' the plugs by which the molding material D is pressed in the matrix. C is the current-carrying coil. Since the magnetic field is the means of carrying the energy to the mold, it will be seen by those familiar with electromagnetism that the part of the mold in the plane of the coil heats most rapidly. The ends of the mold in contact with the platens lose heat rapidly, so that it was found well to protect them against such loss by asbestos or pasteboard sheets at Z. Next, several coils of different proportions were made, long ones for the longer molds and flatter ones for the shorter ones.

It was found inconvenient to lift the hot molds from the interior of the coils, so a further improvement was made in which the coils were divided into two halves and mounted as shown in Fig. 2, in which letters designate the same parts as in Fig. 1. This arrangement gives good heating throughout the mold regardless of the shape. In fact, there is a little greater heating at the ends, which compensates for loss by

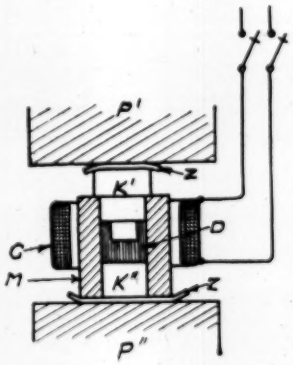

FIG. 1 ELEMENTARY ARRANGEMENT OF HEATING COIL

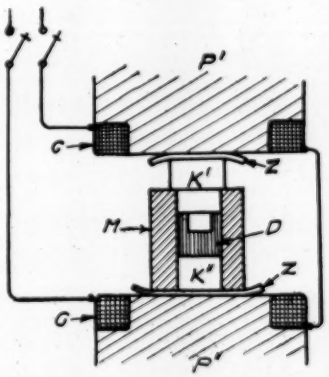

FIG. 2 IMPROVED ARRANGEMENT WITH COILS ABOVE AND BELOW

conduction. The plates P' P'' were fitted with laminated-iron sections so that a path for the magnetic flux in them, which would not develop heat, could be provided. Fig. 3 is a photograph of the press fitted with these coils. It is evident that the molds could be put into or removed from the press thus fitted as readily as from an ordinary press.

In all of these arrangements the magnetic return circuit consists of leakage through the air and through the massive parts of the press, in all of which the magnetism is so diffused that the energy loss is small. This is clear from the fact that such losses are a function of the square of the magnetic density and the electrical conductivity of the material. Cast iron being of low conductivity, losses in the heavy parts of the press are necessarily very small. Cast iron would not be a good material from which to make the molds. It is evident that the thermal efficiency of this method is comparatively high. The writer has good reason to believe that more than half of the heat which is developed makes its appearance in the mold.

By the induction method of heating it is possible to pile several thin molds on top of each other and heat them all at once. This is not possible by any other method. By this

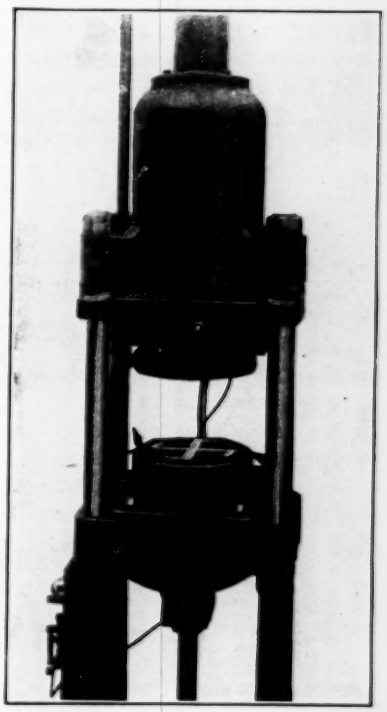

FIG. 3 HYDRAULIC PRESS FITTED WITH COILS AS SHOWN IN FIG. 2

means one press can be made to produce several articles simultaneously.

In making molded insulation the cost of molds is frequently very great. By the induction method of heating the cheapest possible mold can be used, since it is never necessary to so shape it as to admit steam to it, or so as to favor the flow of heat into it from any external source.

Many electrical engineers would regard the low power factor at which such devices operate as a serious drawback. However, the writer regards it as an important advantage in that a steadying effect on the circuit is produced, so that whether a large mold or a small mold, or no mold at all, is placed in the coil, no harmful result will follow, the large size of wire used being sufficient for the current at all times. Measured up in terms of value received for the outlay and freedom from trouble and general convenience, the process was entirely satisfactory. A press having a better magnetic circuit which would have operated at a power factor comparable to that of an induction motor could have been made at a greater cost, but the extra cost would have exceeded the saving possible during the time the above apparatus was in use, which was about one year.

It is believed that other uses might be made of this process; for example, die castings of readily fusible metal might be made economically on a small scale; or hardened-steel parts might be tempered, in which case the temper could be drawn without overheating sharp angles and cutting edges.

NEW THEORY OF AIR-PROPELLER ACTION

By MORGAN BROOKS, URBANA, ILL.
Member of the Society

THE term air screw, considered by many writers on aeronautics as descriptive of propeller action, is a misnomer. The theory of the marine propeller, which seems to be adequately presented by the screw principle, has been transferred to air propulsion without sufficient regard for the extreme difference in the two fluids as to elasticity.

In view of the current theory that air is driven by a propeller with a velocity which should not exceed the product of the pitch of the propeller by its revolutions, it was a surprise to find that air may be driven backward at a velocity nearly twice as great as this product indicates. The fact was so revolutionary that it caused the greatest care in measurement before its acceptance. Recognition of this superspeed action of propellers explains many anomalies of air propulsion and will undoubtedly lead to more exact formulæ for thrust and power calculations.

The purpose of this paper is to give proofs of the above possibility and to point out some of the applications of superspeed theory as it relates to propellers and blowers.

Superspeed is not readily observant with the standard type of two-blade propeller owing to the masking of this effect by the mingling of high-speed air with a much larger quantity of inert air lying between the propeller blades. Therefore the measurements were made upon a special type of propeller having extremely short blades of great width, sweeping the entire circumference of the disk area.

A propeller of the wide-blade type described having an experimental mean pitch of 2.53 ft. gives a wind on static test that flows 3.33 ft. per revolution, regardless of the speed of the propeller. These values were determined for the writer by Prof. E. P. Lesley at the Leland Stanford Jr. University wind tunnel, confirming the writer's own measurements. The superspeed ratio, 3.33/2.53, is 1.32, and these figures bear so direct a trigonometrical relation to the blade angle as to suggest that air instead of being swept backward by screw pressure is driven back by precise reflection or batting action.

The reflection theory is supported by data obtained with a blade of 28 deg. angle and by other confirmatory tests. In this connection an investigation was also made of the more complex condition of a propeller operating in a wind tunnel with wind conditions corresponding to those on a flying plane.

Among other things it was found that for low blade angles, where the superspeed ratio is more pronounced, the air leaves the propeller at higher velocity near the blade tips than part way in, a condition inconsistent with the screw theory for standard-type constant-pitch propellers.

Eiffel in his "Recherches" presents an elaborate collection of data showing that this condition exists, but the reflection theory for the first time explains it.

Light ribbons placed in the air flow from a static propeller show that the air moves in a direction strictly perpendicular to the blade angle, a condition determined by the reflection theory but not by screw action. Moreover, these ribbons indicate that the stream contracts slightly in diameter as it leaves the propeller, whereas with the squeezing action of a screw the air would be expected rather to expand.

The most convincing demonstration of the fact that the air leaves a propeller at a greater velocity than the propeller screw advance is found in a test made with two propellers connected in tandem. Calling the forward propeller a blower for the sake of distinction, assume that it provides a wind at 30 miles per hour, or 44 ft. per sec., and that the propeller is driven by this wind at a speed just above idling speed, such that its revolutions times pitch is, say, 48 ft. per sec. An anemometer shows a velocity of about 50 ft. per sec., but if the blower be shut down while the speed of the propeller is maintained constant, the wind velocity rises to 75 ft. per sec. instead of remaining constant as demanded by the screw theory.

The acceptance of superspeed action gives a basis for the evolution of dynamic thrust equations without the questionable assumption of blade activity over a larger portion of the propeller disk than that covered by the blades alone. The proper interpretation of superspeed may reconcile thrust and power values as derived from static tests with those of wind tunnels or of flight. Today it seems to be the common opinion that flying performance may not be predicted from static tests. With the precise air-dynamics formulæ sure to be developed, a single static test of a propeller should furnish all necessary data for the production of complete flying-performance curves.

The writer shows analytically that apparently the wind-tunnel blower relieves the propeller of a portion of the static thrust at a given propeller speed represented by idling speed, even though the propeller giving superspeed sends air backward when tested statically at the speed V/p, where V is plane velocity and p the propeller pitch. The writer shows that under his formula the flying thrust at 30 per cent slip is found to be 51 per cent of the static thrust at the given propeller speed.

The writer does not believe that correct air-dynamics formulæ will produce essential changes in propeller design, but hopes that the paper may lead to a clearer conception of the underlying physical principles of air propulsion.

For presentation at the Spring Meeting, Worcester, Mass., June 4 to 7, 1918, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained by members gratis upon application. All papers are subject to revision.

A HIGH-SPEED AIR AND GAS WASHER

By JOHN L. ALDEN,[1] WASHINGTON, D. C.
Member of the Society

THIS paper describes a new type of air and gas washer which has been developed within the past eighteen months, and which offers the following advantages over the existing types:

1 The washing can be continued to any desired degree of cleanliness.
2 The washer will handle unusually large quantities of dust or long fiber without clogging, owing to its large passages and entire absence of eliminators.
3 Due to the high washing efficiency, the water consumption is very low, from 1 to 2 gal. per 1000 cu. ft. of air.
4 The washer is extremely small and compact, and of light weight. A 10,000-cu. ft. washer is about 5 ft. long, 5 ft. in diameter, and weighs less than 400 lb.

In this paper the term "air" will be used to include any

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gaseous fluid or vapor for which cleaning apparatus may be suitable.

The writer has believed for some time that air washing and gas cleaning have been approached from the wrong angle, and that most builders of apparatus for this purpose have not taken advantage of all of the natural laws governing the depositing of air- or gas-borne particles. The result has been the general adoption of crude and unmechanical designs, and has made necessary the use of low velocities of gas through the machine. Gas scrubbers normally operate at a velocity of about 90 ft. per min. and air washers at from 400 to 500 ft. per min., while with these devices the limiting velocity for good washing and a reasonable frictional resistance is about 1000 ft. per min. The washer about to be described operates habitually at from 2000 to 5000 ft. per min. As the efficiency of air cleaning in this type increases rapidly with the velocity, the only limit to the latter is the resistance imposed.

Fig. 1 represents a longitudinal section of the air washer referred to above. A helical passage is constructed within a horizontal drum, provided at one end with a tangential inlet for the dirty air and at the opposite end with an outlet for the purified air. That portion of the helical passage nearest the inlet constitutes the washing chamber, while the remainder comprises the eliminating element. On the inner wall of the helical duct are suitable spray nozzles which spray across the column of air. Depending upon the amount of dust to be removed and the completeness of washing desired, the air makes from 1¼ to 5 screwlike revolutions in passing through the helix from inlet to outlet. For fairly dusty air or for the ordinary dust-collecting system, two turns are sufficient. The whole or a portion of the first turn is used for washing while the last turn is employed for the elimination of the free moisture.

The common commercial air washer with which we are all familiar depends upon its spray nozzles to throw down the dust particles and upon the eliminator plates to catch and retain the particles which have not actually been met by the sprays. The immediate result is low washing efficiency, if we consider water consumption as a measure of washing efficiency. In the first place, it takes an enormous quantity of water divided into a large number of small drops well distributed over the entire washing area to insure the wetting of any considerable portion of the dust. It is necessary that each particle of dust deposited be brought into intimate mechanical contact with a drop of water. The deflection of the air currents through the zig-zag eliminator plates introduces a very limited amount of centrifugal washing when the eliminators are kept flooded. On the other hand, a washer depending upon centrifugal force alone to throw the dust particles out of the air column is limited to the handling of the coarser dusts and will not remove the minute particles which make up the bulk of the dust content of the atmosphere. The washer described in this paper makes use of both spray and centrifugal washing, with the greater dependence placed upon the latter. As the dust-laden air enters through the tangential inlet pipe it is thoroughly wetted by the mist of the spray chamber. Much of the coarser dirt is removed by the direct action of the spray. As the air is whirled through the helical conduit a large proportion of the remaining dust is thrown against the wet curved side of the washer, flowing off to the drain with the spent wash water. The extremely fine dust still remaining cannot be caught by ordinary means, for it is too light to be separated by centrifugal force. However, a considerable amount has been exposed to the mist to such an extent that, although not actually wet, its specific gravity has been increased by the moisture to a degree which will permit its removal centrifugally. Thus, an unusually high proportion of the dust content is removed.

After the washing operation the air passes through the eliminating portion of the washer, where it is freed of the suspended moisture. The elimination of water drops is effectually accomplished by centrifugal action, exactly as the dust itself was removed. It is unnecessary to introduce into this washer any form of eliminator plates such as are found in most commercial washers.

The high washing efficiency thus gained presents two possibilities, either of which is decidedly advantageous. Extreme dust conditions may be met with comparative ease; or, street air may be washed for ventilating purposes with an unusually small amount of water. One of the smaller sizes of these washers handles 4000 cu. ft. per min. of dusty air from a dust-collecting system, and from 50 to 100 lb. of mud is removed daily from the

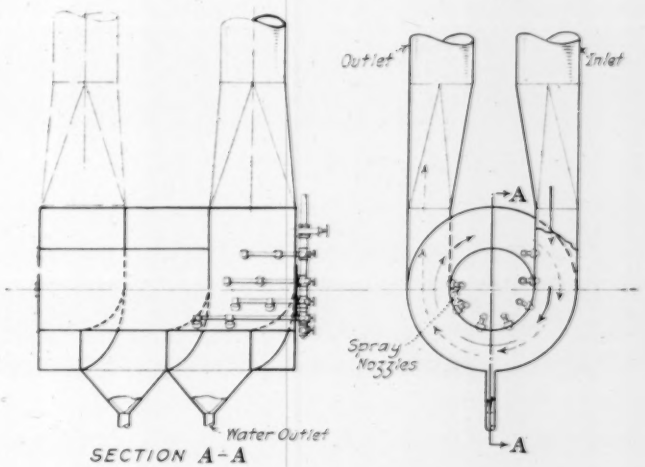

FIG. 1 CENTRIFUGAL AIR WASHER SHOWN IN SECTION

strainer basket. From 4 to 6 gal. of water per minute wash this dirty air to a sufficient degree of cleanliness to permit it to be returned to the room. While no measurements have been made of the dust content, this air has absolutely no dusty odor and has a decidedly pleasant, fresh "feel." These results, obtained from a practical commercial washer, not a laboratory product, show that air sufficiently dirty to show a decidedly smoky dust cloud can be washed with from 1 to 1½ gal. of water per 1000 cu. ft. That this air washer is clearly a step forward is shown by these figures, for the standard washer requires from 4 to 5 gal. per 1000 cu. ft. to successfully wash air which is initially much cleaner than that on which the centrifugal washer was tested. Where it is impossible to recirculate the wash water, the economy in water alone is an appreciable item. For a machine to handle 10,000 cu. ft. of air per min. this amounts to 20,000 gal. per day of 10 hours. In addition to the actual cost of the water, the cost of pumping and the initial cost of pumps, motors, piping, etc., is considerably reduced.

Any material which may be separated from air by means of washing may be removed in this type of washer in any practical degree of thoroughness desired. This is accomplished by increasing the number of turns of the helical washing space. Thus, for ordinary ventilating purposes, 1 to 2 turns are sufficient; for dust collecting, 1½ to 3 turns; while for extremely fine dust, from 3 to 5 or more turns must be used. The economical limit is probably about 5 or 6 turns, or convolutions. The overall length, as determined by the number of turns of the

screw-shaped conduit, depends, therefore, upon the degree of purity of air desired, and to a very much less extent upon the relative arrangement of inlet and outlet. The outside diameter, on the other hand, depends upon the air volume. Since centrifugal force plays such an important part, the size of the washer is greatly reduced because the efficiency increases as the diameter decreases. In addition, the efficiency increases very rapidly with the higher air velocities. Both factors tend toward the production of a small, compact washer. The reason is very evident from the expression for centrifugal force:

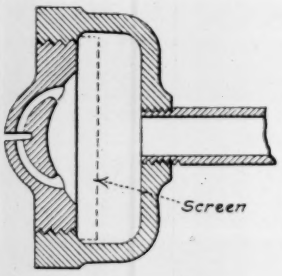

FIG. 2 SPRAY NOZZLE FOR USE IN AIR WASHERS

$F = mv^2/r$, where v = air velocity, ft. per sec., r = radius, ft., and m = mass. Thus, if satisfactory cleaning is done with a washer of 2 ft. mean radius of the washing chamber at 3000 ft. per min. velocity, an 8-ft. washer would require a velocity of 6000 ft. per min. to give equally good cleaning. It is therefore desirable to make the diameter of the washing drum as small as possible and at the same time use as high a velocity as is consistent with a reasonable friction loss. Owing to the fact that with increased diameters higher air speeds must be used to give the same cleanliness, it is probable that the practical limit of size for ordinary air washing is between 15,000 and 25,000 cu. ft. per min. High-speed air washers may be built in sizes as small as 100 cu. ft. per min., but both the upper and lower limits of size may be extended to meet unusual requirements. Table 1 gives the approximate dimensions of centrifugal air washers to be used for ordinary ventilating purposes. For other and special cases the dimensions will, of course, be different. It will be seen that in every case the washers are very small for the capacity; those already built and installed have been so small and light that they have been hung from the ceiling with band-iron straps, leaving ample headroom beneath.

TABLE 1 APPROXIMATE DIMENSIONS OF CENTRIFUGAL AIR WASHERS FOR VENTILATING PURPOSES[1]

Capacity, cu. ft. per min.	Diameter, inches	Length, inches
2,000	30	36
4,000	40	42
6,000	48	52
9,000	56	60
12,000	64	72
16,000	72	80
22,000	80	90
30,000	96	108

[1] The exact dimensions vary with the air volume the character of the dust, the relative positions of the inlet and outlet, etc.

The new washer described in this paper will supply a field hitherto untouched by the standard air washer. The latter is utterly unsuited to the handling of large quantities of fibrous materials, cotton, jute, hemp, wool, and miscellaneous waste. Large amounts of fine dust, shavings, or any other materials ordinarily handled by exhaust systems are beyond the capability of the common air washer. These substances will either clog the eliminators or will pass completely through the ordinary commercial machine. On the other hand, it is extremely difficult to clog the centrifugal air washer with dirt and refuse, owing to the large passages and to the entire absence of eliminator plates or other obstructions. It is unnecessary to interpose between the washer and the source of dust any form of dust collector or rough washer. Since the dirt and water are removed at each convolution of the helix, there is no accumulation of water and material to be reëntrained by the air current. This is an essential feature where the centrifugal removal of free moisture from a high velocity current is attempted.

With the air flowing through a rectangular passage, it is desirable to throw a flat spray of water across the channel. After considerable experiment with a variety of forms, the nozzle shown in Fig. 2 was designed to fulfill these requirements. The spraying tip is part of a removable plug containing two holes designed to throw opposing streams. The impact of the jets forms a flat sheet of spray at right angles to the plane of the holes. Although this spray is quite fine, much of it is further broken into mist upon striking upon the opposite wall of the washer. Locating the spray nozzles upon the inner wall of the chamber makes it necessary for all of the dirty air to pass through this fog-filled passage. This arrangement is much superior to that whereby water is allowed to flow from perforated pipes or nozzles over the outer cylinder alone, as it insures a thorough wetting of the dust taking place.

The pressure loss through the washer is from ⅛ in. to 1 in. of water, depending upon the conditions governing the design. The variables to be considered are the diameter, the cross-sectional area and proportions of the washing space, the velocity, the number of turns of the helix, and the volume of water per square inch of the sectional area of the washing chamber. Ordinarily, this washer can be designed for ventilating work with a resistance of about ¼ in. of water. Where the dust requirements are more severe, demanding higher velocities, more wash water and a greater number of convolutions of the helix, the loss will be somewhat greater.

Unfortunately, the writer is unable to give additional details of the performance of this washer, as his investigation of the first commercial installation was interrupted in May 1917 by the war. However, it may be said that two others were built from his design, and although he has not seen these either during construction or operation, they are reported by the owner to be in successful operation. Each of the later washers has a capacity of 15,000 cu. ft. per min., and was designed to hang from the ceiling with 7 ft. of headroom beneath. This type of washer was designed and developed for a specific job, that of washing the clouds of dust from the fan blast of dust-collecting system, leaving the air fit for breathing. The first experimental installation and the subsequent machines showed that for this purpose the washer was eminently satisfactory. The severe test of dust-collecting work, removing great quantities of dust from the air and returning the purified air to the room, justifies the belief that the centrifugal washer will easily satisfy ventilating requirements. Owing to the similarity of refined dust washing and blast-furnace-gas scrubbing, an investigation of the adaptability of this washer to gas cleaning would seem well worth while.

A SELF-ADJUSTING SPRING THRUST BEARING

BY H. G. REIST, SCHENECTADY, N. Y.

Member of the Society

THRUST bearings for supporting the heavy loads of water wheels and the electric generators driven by them, are now very widely used. The difficulties in the fitting and use of plate bearings are much aggravated as the weight is increased, on account of the large overall dimensions of the supporting plate. It is true that the surfaces can be fitted quite accurately by machining, but the writer has known cases where the surfaces were turned slightly conical so that they touched hard on the inner or the outer edge. The deflection of the supporting collar on the shaft may allow the runner to be slightly dished, or there may be a deflection of the supporting surface, thereby dishing the babbitted seat or causing one side to be lower than the other. The self-adjusting spherical seat provided to correct some of these difficulties is of doubtful value on large bearings on account of the great frictional resistance which must be overcome to make it shift.

FIG. 1 SPRING THRUST BEARING, FOR VERTICAL WATERWHEEL-DRIVEN GENERATOR, TO CARRY A LOAD OF 300,000 LB. AT 100 R. P. M.

(View shows rubbing surfaces of both rotating and stationary rings, the latter being raised to show the arrangement of springs)

Thrust-bearing surfaces are usually scraped to each other, or to a surface plate, to avoid dangerously high spots; but, since the oil film is of the order of 0.0002 in. to 0.0003 in. in thickness, the difference in level must be smaller than these values. This work must usually be done without load, and no matter how carefully done, when the bearing is loaded the parts will probably not fit each other, due to deflection.

A careful study of the above difficulties led the writer to the design of a flexible bearing surface pressed against the runner by springs. It seemed that this would prevent the possibility of undue pressure at any point, and compel each element of the surface to carry its share of the load. On trial, this solution proved satisfactory.

A typical design of a spring thrust bearing for vertical-shaft machines is shown in Fig. 1. The bearing consists of a runner of a special grade of cast iron resting on a thin steel ring with a babbitted surface. The babbitted stationary ring, in turn, rests on short helical springs and is held against rotation by dowel pins. A saw cut through one side eliminates any tendency of the ring to dish with a change in temperature.

FIG. 2 SPRING THRUST BEARING WITH "COMPRESSED SPRINGS" FOR MACHINES HAVING SMALL CLEARANCES

(The stationary babbitted ring is raised to show springs and dowel pin)

The high base ring shown, on which the springs stand, is often used in connection with a deep housing to increase the amount of oil in the surrounding bath. The tube in the center forms a retaining wall around the shaft, for the oil. The springs ordinarily used are wound of ½-in. round wire and have an outside diameter of 2 in. and a free length of 1½ in. Under load the springs close about $\frac{1}{16}$ in. and the total pressure is well distributed. By this means it is possible to avoid excessive pressures at any point. Thus, it is safe to run with a much higher average pressure than when there is no definite limit to the pressure which may occur over a small area.

It will be seen that this type of bearing differs from the solid-ring thrust bearing in that one of the bearing surfaces is made to yield at any point by using a comparatively thin plate supported by a large number of springs. While solid bearings may be used successfully for small loads, a bearing which thus automatically adjusts itself to faults in finish and in alignment is preferable for carrying very heavy weights.

Oil grooves are provided in one of the members and sometimes in both. In order to insure proper circulation of the oil

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for cooling purposes, in the case of bearings operating at low speed it is necessary to have grooves in the rotor. On high speeds these grooves may sometimes be omitted, relying for circulation only on the friction of the rotor on the oil while passing the grooves in the stator. In many cases we have had very satisfactory results by placing radial grooves in both the rotating and the stationary surface. It is our practice to have different numbers of grooves in the two plates, for instance, six and eight. With grooves in each of the surfaces we have a continuous flooding of oil on all the bearing surfaces and a very effective means of cooling. Much of the heat would otherwise have to be transmitted through the metal of the stationary part of the bearing.

The pressure usually allowed on these bearings is from 300 to 400 lb. per sq. in., the design permitting a very thin oil film without metallic contact. It is necessary to have the runner very smooth and free from scratches, especially any at an angle to the direction of rotation, as these might cause injury to the babbitt. The babbitted surface does not need to be scraped but is turned with a tool as smooth as is convenient. Wearing sometimes occurs in minute spots all over the plates. When this happens, there is no risk of dragging the metal. The bright spots that show themselves are produced while starting and slowing down, before a pressure film is formed. When in operation the weight is apparently entirely supported on the oil film.

It is desirable to run bearings at a high pressure if they can be designed to do this safely, as the parts then are smaller, the rubbing speed is less, and the friction very much reduced. With this design of bearing the tendency to excessive pressure at one point is automatically relieved by the springs yielding, and while there will be some uneven distribution, a variation in pressure of two or three times the average is comparatively unimportant and does not cause bearing failures,—it is pressures of twenty or more times the average that cause injury. These excessive pressures are prevented by the construction just described. For this reason it is safer to operate this bearing with high pressures than a more rigid bearing at lower pressures.

The loss of alignment due to settling of foundations or other causes does not affect the bearing adversely. In one water-wheel-driven alternator installation the striking of the field against the armature led to the discovery that the coupling between the two units had loosened, which allowed the shaft to "run out." The bearing operated without injury with over 0.03 in. vertical movement of the outer edge of the rubbing surface. This caused an uneven distribution of load on the bearing, to the extent of reducing the load on one side of the bearing about 16 per cent, and increasing the pressure a similar percentage on the extreme opposite side.

An advantage of increased pressure in the reduction of friction is shown by the following table of comparison:

Bearing number	1	2
Rev. per min.	200	200
Total load, lb.	300,000	300,000
Outside diameter of bearing, in.	35	46
Inside diameter of bearing, in.	17.5	17.5
Net area, sq. in.	600	1200
Pressure, lb. per sq. in.	500	250
Average rubbing speed, ft. per min.	1370	1670
Coefficient of friction	0.0018	0.0033
Kilowatt loss	16.7	38
Horsepower loss	22.5	51

In some designs the vertical clearance between the water wheel and the casing is very small, so that the displacement caused by a free spring under the variation of hydraulic suction is objectionable. In such cases an initial compression equal to full load, or to an overload, is put on the springs. The load will still distribute, since an overload at any point will cause the spring to close beyond the initial compression. Such a bearing is shown in Fig. 2. However, this bearing was designed to replace a roller bearing, and was so made that the parts of the water wheel would occupy the same relative positions as before. The principles used in the construction of these thrust bearings are applicable also to journal bearings and to bearing surfaces having a reciprocating motion, like the crosshead of a steam or gas engine.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal, or brief articles of current interest to mechanical engineers.

The High-Speed Motor and the Fuel Question

TO THE EDITOR:

In the past three or four years automobile engineers have developed a modified type of gasoline motor with piston speeds greatly in excess of what was considered proper and safe before.

Several causes are back of this development: first, the ability of the forging plants of the country to produce crankshafts with integral counterweights, which reduce the pressure on the bearings to a safe limit; second, the demand for smoother-running engines; third, the work done to develop lighter and more efficient power plants.

For some time it has been a question in the mind of the writer whether, in that search for higher speed, a cardinal point has not been overlooked—to the detriment of motor efficiency—in failing to take into account the vaporizing qualities of the fuel at our disposal during the past years.

In discussing this question of high-speed motors and fuel it must be remembered that the high-speed motor originated in Europe with the racing motors brought out by European designers in 1912, 1913 and 1914; and as the gasoline which they used was of a very high grade, they were successful in developing that type of motor; but our fuel being of a much lower grade, principles of design that can be used in Europe do not apply to conditions on this continent.

It is a fact that the quality of fuel sold as gasoline to the automobile owner has been gradually declining year by year. The enormous demand made upon the oil industry for a volatile fuel has resulted in the marketing of a fuel containing less and less of the main volatile elements of gasoline. The gasoline of the early days consisted mainly of pentane, hexane and heptane—elements which are very volatile and, conse-

quently, easily vaporized. Until 1914 the gasoline used in Europe was of that composition, while ours had already started on the decline. Since that period gasoline has passed from a by-product of petroleum to a main product, and therefore the heavier elements of petroleum have had to be incorporated in increasing volume to keep up with the demand. These elements comprise octane, nonane and decane, which are hard to ignite when mixed with air. However, if heat is applied to them before admitting them into the cylinder their inflammability is very much improved. These points being kept in mind, let us see what happens when we try to run a high-speed engine with these grades of fuel.

Not so very long ago 1000 ft. per min. was considered an average and efficient piston speed, but automobile designers, for the reasons stated above, tried to increase piston speeds to a point near 3000 ft. per min. Without entering into details of the improved lubrication necessary to take care of the increased friction, we find that the time given to the explosive mixture to reach the cylinder, to be compressed, exploded, and evacuated, has been reduced to one-third of what it was formerly. If the fuel used was very volatile, as the gasoline of older days, we might still consider it possible to burn the full charge of gas in the cylinder and evacuate it. But the fuel being much poorer, we think it is a physical impossibility to mix properly an explosive gas and burn it entirely in the limited time left for the explosion to take place. This is proved practically by the reports received from users of cars, principally of the higher-speed types. It is found that a portion of the mixture does not burn: it passes by the piston rings and goes down into the crankcase, where it dilutes the oil to the danger point, resulting in burned-out bearings and seizing of parts subject to friction. It is therefore evident that a speed of 3000 ft. per min. for pistons is not practical. Let us see what piston speeds we find in the best-developed engines at the present time.

It is a recognized fact that the highest form of gasoline motor today is the engine used in aeroplanes at the front. A comparison of the piston speeds used in the most modern battleplane motors of France, Germany, the United States and England discloses the fact that the highest piston speed maintained does not exceed 2000 ft. per min., and is closer to 1600 ft. per min. than to 2000—nearly half the piston speed used in the so-called high-speed motors. There is room for thought in this. It is our own opinion that these speeds are even a maximum which the commercial automobile motor used in either passenger cars or trucks should not exceed, and engineers who will study these motors in the future with this idea in mind will be more successful with their product than those who cling to the high-speed principle.

This fuel question is so complex that some other points have also to be considered. We shall mention the most important one—the starting of a motor in cold weather. Every one who is familiar with the driving of an automobile knows that in the cold morning temperatures which we experience on this continent great difficulties are encountered in starting the motor with some types of cars. Some of them will start easier than others, but from the writer's experience the starting qualities can be improved greatly by reducing the section of the inlet passages into the cylinders to permit of higher gas velocities. Also, if the carburetor is set very close to the cylinder, permitting the heat of the exhaust to warm up the inlet pipe, still better results can be obtained. The reducing of the inlet passages by tapering them gradually into the cylinder produces a better mixture which is exploded more readily with less residue and less carbon deposits in the explosion chamber and on the spark plugs. The writer has applied these principles to several engines designed in the past four years with marked success, and he has at the same time tried to limit the piston speed in these motors to a maximum of 1600 ft. per min., this design being in line with the ideas set forth above.

We are of the opinion that the qualities which attracted designers to the high-speed idea in gasoline motors can be taken care of as well with the slower types of engines and permit at the same time a better solution of the lubrication problem.

E. PLANCHE.

Flint, Mich.

Report on Pulverized Fuel

TO THE EDITOR:

I am enclosing an abstract of a report recently made to the President of the U. S. Shipping Board, on the use of powdered fuel for marine purposes. This report was prepared by the Fuel and Fuel Handling Committee of the Naval Consulting Board, of which the writer is chairman, in response to the following resolution by the Naval Consulting Board, November 17, 1917:

RESOLVED, That in view of the efficiency, economy and smokeless conditions which would accompany the use of powdered coal on ships, the Naval Consulting Board recommends to the United States Shipping Board that a thorough investigation be made of this subject and a trial plant be installed.

SPENCER MILLER.

New York, N. Y.

ABSTRACT OF REPORT

Pulverizing coal as a fuel is extensively employed in the arts for smelting, for burning portland cement and to a limited extent for generating steam. It is estimated that 50,000,000 tons of coal has been pulverized and consumed within recent years in the United States. In stationary practice definite economies have been claimed over the use of solid coal. From the above it appears that the art of pulverizing and burning coal as a powder has passed the experimental stage in certain arts.

From evidence placed before us pulverized coal is a smokeless fuel, a fact of considerable military importance.

By a simple and immediate adjustment of the burners, powdered coal as a fuel may be made to emit dense clouds of smoke to serve as a screen, another fact of military importance.

In an emergency the ship's boilers may be rapidly forced, thereby increasing the steam supply and the speed of the vessel. This is a fact of military importance.

A great reduction in the fire-room force is effected over using solid coal. This saving in man power has military value.

The supply of fuel oil in the United States is limited, and as a means of conserving fuel oil for naval vessels equipped to burn oil exclusively the Consulting Board feels justified in encouraging the use of powdered coal as a fuel for merchant ships.

The Fuel and Fuel Handling Committee was canvassed to vote upon the two following questions:

a Is it feasible to carry powdered coal on merchant or naval vessels such as would be used in transatlantic service?

One replied in the affirmative and three in the negative.

b Is it feasible to install on any such ships apparatus to powder coal?

Four replied in the affirmative and one in the negative.

From the above it will be noted that, in the opinion of the Committee, which has been approved by the vote of the Board, it appears feasible to equip merchantmen with requisite machinery for pulverizing and burning coal, and we therefore earnestly recommend that the Emergency Fleet Corporation authorize the preparation of the necessary plans and drawings for such an installation upon such ships, and that a shore installation be made of such equipment to determine as well as may be the value of such an installation on board ship. Such shore installation can be set up and tested at the Annapolis Experiment Station, Annapolis.

A ship equipped with pulverizing equipment should, in the opinion of the Naval Consulting Board, be expected to take on coal in any port of any kind available and by the ordinary methods. In Atlantic ports this will be run-of-mine bituminous of high volatile and of high grade, sometimes dry and dusty and at other times quite wet.

Such coal on board ship, following shore practice, would then pass through the following processes:

Crushing in power rolls, and delivering to a storage bin.

Drying if found essential to remove the moisture prior to pulverizing, delivering to a second storage bin.

Extraction of iron particles. This being advised to save damage to the pulverizing mill. A magnetic separator is commonly used for this purpose.

Pulverizing, either in Fuller or Raymond mills or their equivalent, then storing in a third storage bin.

Mixing with air, feeding to furnace and burning.

After delivery of the raw coal to crushers the fuel will be handled by conveyors or spouts. All storage bins, conveyors and spouts must be constructed and maintained dust-tight as a means of preventing explosions, and possibly such may have to be made of non-corrosive material.

The Naval Consulting Board is at your service, and if it be your pleasure to proceed in the preparation of designs, estimates and specifications, we shall be honored by your seeking our aid in the solution of this important problem.

A Suggested Extension of the Scope of A. S. M. E. Transactions

TO THE EDITOR:

The Publication Committees of recent years are to be congratulated upon the character of our publications. There was a feeling of dismay among some members a few years ago when the discontinuance of the TRANSACTIONS was proposed. Happily, this situation has been adjusted, so that there are now only expressions of satisfaction.

It has occurred to me that we could with benefit include in our TRANSACTIONS more papers of general scientific value than has been customary. Such papers would not be of sufficient current interest to be discussed at either local or general meetings, but would be of such character as to be of future value to specialists in particular branches of our field. To use a slang expression, which, as is often the case, conveys a great deal of meaning in a terse way, I plead for the publication of more "high-brow" papers in our TRANSACTIONS. Of course, an innovation is not to be expected during these war times. However, the matter can be discussed and planned for, so as to be in operation by the time the war is over.

Our country is already taking an advanced position in the affairs of the world in many directions. We have, however, been somewhat backward in the matter of learnedness. There are French, English and even German publications extending back a century or so which contain epoch-making papers. Many of these papers had little or no current interest, and yet they are the foundation stones of our present scientific structures. We, in this country, must also lay such foundation stones for the benefit of our posterity if we expect to take the place in the world's affairs which we seem to be seeking. There are in this country at the present time but few places where abstruse mechanical-engineering papers can be published, as compared with England, France and Germany. Hence it seems necessary that our own TRANSACTIONS should be arranged so as to include such papers in greater number. The money put into their publication would, of course, not yield us immediate dividends, but would be a contribution to our successors. The net result of publication of such papers would be references to them by specialists of the future. Our own TRANSACTIONS would then stand alongside those of foreign societies as valuable works of reference. The value of an abstruse paper is measured by the number of times it is referred to in footnotes of later papers.

The lack of a vehicle for the publication of papers of the character described has, of course, discouraged abstruse mechanical-engineering research. The provision of a vehicle would, doubtless, stimulate research.

In order that this plan can be executed, two things are necessary:

(1) To secure an increased number of meritorious papers of the character described;

(2) To arrange for their publication.

Progress in either one of these directions will, of course, assist progress in the other. Our Secretary, Editor and Publication Committee are already in touch with various research laboratories engaged in mechanical-engineering work connected both with colleges and commercial establishments, and are endeavoring to secure papers from them. This effort should be assisted in every way by the membership. Many commercial establishments have been very broadminded in recent years in allowing the work of their research laboratories to be published. I have no doubt that papers from such sources will increase, particularly as there seems to be an increase in the amount of commercial research work being done.

After such papers have been secured they might be passed upon for publication by our Research Committee. The Meetings and the Publication Committees would then pass on to the Research Committee a paper which they decided was not of sufficient current interest to be read and discussed at a meeting. The Meetings Committee, of course, read a paper from an entirely different point of view from that of the Research Committee. If the Research Committee decided that the paper was meritorious, from their point of view, they would direct the Publication Committee to publish it. Such an arrangement would also give the Research Committee more direct responsibility in regard to securing such papers.

I understand that it has already been proposed that papers of the character referred to be printed in advance form, circulated previous to a meeting, read by title only at a meeting with request for written discussion, and published in the TRANSACTIONS if it finally seems advisable. If the Research Committee were made responsible in such matters they would direct the Publication Committee regarding both advance and final publication.

I have no doubt that a very satisfactory arrangement of such details can easily be managed if we can secure a sufficient number of good papers of the character described.

SANFORD A. MOSS.

Lynn, Mass.

Urgent Need for the Inventive Ability of Mechanical Engineers

TO THE EDITOR:

In connection with the statement in regard to the work of the War Committee of the Engineering Council, printed elsewhere in this number,[1] I desire to urge that the mechanical engineers of the United States should give their thought and consideration, and above all should put their imagination to work, in order to invent new types of apparatus for waging war. It is the quality of imagination which will count in the fight. It is especially the imagination of the man who is technically trained which is of the greatest value. As a direct method the mechanical engineers of the country should give consideration to and make a study of the various types of weapons now in use, with the object of determining whether these types as they now stand are in fact the ultimate types. This sort of study will unquestionably stir the minds of technically trained men into the invention of many new types of weapons.

The theory on which the War Committee of Technical Societies, of which Mr. David W. Brunton is chairman, is based, is—that if the vast body of technically trained men in the United States could be stirred into consideration of weapons and apparatus of war, then there would be brought forth without question valuable types of weapons and apparatus which are at the present moment unheard of. Most of the present weapons have been brought forth in the manner of slow evolution, as has also been the case in the development of most machines. However, it is believed that by stimulating such an enormous number of minds the period of time of evolution will be shortened. It is further believed that valuable weapons may be produced by the combination of old and thoroughly evolved machines and ideas into new and effective machines.

It must be remembered that past experience has shown that the invention of valuable war apparatus and weapons has by no means been confined to the members of the Army and the Navy. It is a well-known fact that some of the most important war inventions have been those of civilians. This of course is also true in every industry; that is, valuable inventions in any given industry are very often made by men who are in nowise connected with that industry. This is due undoubtedly to the opportunity of the outsider to consider and judge without prejudice.

It is thoroughly well known that previous to the war inventions of civilians in connection with war apparatus were not cordially received by the Army and the Navy, and the situation in this country at that time was such that very few civilians were willing to lend assistance to the Army and the Navy. The day of these conditions is now past, however, and the day of great urgency has arrived. The ideas and inventions of the civilian trained engineer are of the utmost value to the Government and are cordially received. The mechanical engineer must enter into the fight, and he will be welcomed, as will also his ideas if they are good. Furthermore, the old handicap of cost and the handicap of the expense of investigation do not now exist, for the money and the credit have been provided and will be provided to meet the situation.

It is indeed the day of magnificent opportunity for the mechanical engineer!

R. N. INGLIS.

New York, N. Y.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in THE JOURNAL, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 187-189, inclusive, as formulated at the meeting of March 28-29, and approved by the Council. In this report, as previously, the names of inquirers have been omitted.

CASE NO. 187

Inquiry: Will not a method of suspension for h.r.t. boilers over 78 in. in diameter involving suspension in battery, using channel or I-beam girders resting on brick work with strap hangers and U-rods, meet the requirements of Par. 323, where the weight of the boiler is distributed uniformly and evenly over the setting walls, and very little, if any, of the weight comes on the firebrick lining? It is not believed advisable to place supporting columns of either cast iron or steel in a battery wall.

Reply: It is the opinion of the Boiler Code Committee that, as specified in Par. 323 of the Code, all h.r.t. boilers over 78 in. in diameter must be supported entirely independent of the side walls of the setting, in order that the side walls may be kept entirely free from troubles from settlement and cracking due to the weight of the boiler structure. This practice is known to be extensively followed by engineers, and is believed to be a necessary requirement for safety.

CASE NO. 188

Inquiry: Is it allowable under the rules of the Boiler Code to flange the head of a round boiler of $11\frac{3}{4}$ in. radius, $\frac{7}{16}$ in. thick, on a 1 in. radius without heating?

Reply: The Committee considers the practice of flanging heads of boilers cold to be unsafe.

CASE NO. 189

Inquiry: Is there a rule in the Boiler Code with regard to the use of single reinforcing straps where this type of construction is used to secure additional efficiency in tube elements? It is believed that by this construction, eccentricity of loading is worked beyond a reasonable limit, and that double straps, internal and external, should be used where reinforcement for tube elements is necessary.

Reply: The Committee agrees that for the particular purpose referred to, a double strap construction is better practice,

[1] Page 402, Society Affairs Section.

but it is deemed inadvisable to make a ruling that would prohibit generally the single strap reinforcement.

REVISION OF BOILER CODE

THE Council of the Society directed that a hearing be conducted in accordance with the recommendation in the Boiler Code that a meeting at which all interested parties may be heard be held at least once in two years to make such revisions as may be found desirable in the Code, and to modify the Code as the state of the art advances. The first of these meetings was held at the Society's headquarters in New York, December 8 and 9, 1916.

The Council also directed that the proposed revisions in the Boiler Code be published in THE JOURNAL, with the request that they be fully and freely discussed, so as to make it possible for any one to suggest changes before the Rules are brought to the final form and presented to the Council for approval. This has been done, and the revisions were presented in the March issue of THE JOURNAL, pp. 234-247, and in the April issue, p. 316, in the form proposed for submission to the Council, except as they may be modified by editing without change of sense. Discussions should be mailed to Mr. C. W. Obert, Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y., and they will be presented and acted on by the Boiler Code Committee. Since the publication of the March issue of THE JOURNAL certain typographical errors have been discovered in the revisions there presented, and corrections of these were published in the April issue of THE JOURNAL; these are supplemented by additional corrections appearing below.

Any further discussions or criticisms, in order to receive consideration by the Boiler Code Committee before the new edition of the Code is published, must reach the office of the Secretary on or before the 15th of May.

PAGE 2

LETTER TO THE COUNCIL.

In the Letter to the Council, after the third paragraph of the matter published in the March JOURNAL, add two new paragraphs to read as follows:

> Your Committee have met monthly for the purpose of considering inquiries relative to the Boiler Code. The procedure in handling each Case is as follows:
>
> All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all members of the Committee. The interpretation in the form of a reply is prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is then submitted in typewritten form to each member of the Council of the Society, and to each member of the Committee. Where a single adverse criticism is received respecting any one of the interpretations, the inquiry is referred back to the Committee. Where there is no adverse criticism, the Council of the Society approves the interpretations which are then issued to the inquirer and simultaneously published in THE JOURNAL. In publishing the replies in THE JOURNAL, the names of firms and parties making the inquiries are withheld. Where there has been urgent need for haste, the Executive Committee of the Council of the Society has acted for the Council.
>
> In accordance with your instructions, each State and Municipality that has adopted the Boiler Code has been invited to appoint a representative to act on a Conference Committee to the Boiler Code Committee, such Conference Committee to consist solely of representatives of the States and Municipalities that adopt the Code. The States and Municipalities have responded by appointing representatives, who have attended the meetings and coöperated in the work of the Boiler Code Committee.

After the seventh paragraph of the matter published in the March JOURNAL, add four new paragraphs to read as follows:

> In the specifications for boiler plate steel, the range in tensile strength in pounds per square inch for firebox steel has been changed from 8000 to 10,000 lb., the tensile strength now specified being from 55,000 to 65,000 lb. per sq. in., which is the same as for flange steel. Your Committee believes that although there are certain features of the specifications for firebox steel which differentiate between the physical properties as compared with flange steel, that there should be a further differentiation. This feature has been taken up with the Sub-Committees of the American Society for Testing Materials, and of The Association of American Steel Manufacturers; but an agreement has not yet been reached. It was considered desirable not to delay the issuance of the revised Code until there could be an agreement; but to transmit the Code to you with the specifications in their present form, with the understanding that as soon as an agreement is reached a supplementary report will be submitted to you for your consideration.
>
> Additional tests for firebox steel, which in the opinion of the Committee would entail the least hardship with a maximum benefit, would be homogeneity tests on the bend test specimens, which are taken transversely from the middle of the top of the plate; the homogeneity tests to be made on the bend test samples after the bend tests are completed, thus requiring no additional specimens to be taken from the plate. Homogeneity tests are now specified for firebox steel on the tension test specimens taken from the lower part of the plate; and in the opinion of your Committee, it would be desirable to make additional homogeneity tests on the samples from the top of the plate where the metal is more apt to be segregated than near the bottom of the plate.
>
> The requirements for the homogeneity tests, at the top of the plate, may necessarily be different from those at the bottom of the plate; and until the requirements for the homogeneity tests at the top of the plate are determined by tests, the specifications cannot be changed to include the requirements.
>
> The rule for determining the strength of diagonal ligaments between tube holes in a drum, which is given in the preceding edition of the Code, has been found to be defective. Experiments have been made with a view of establishing a more exact rule. The experiments so far made indicate that certain theoretical curves which are published herein, in connection with Par. 193, are safe and accurate, and these curves are therefore offered for determining the efficiency of such ligaments. The experiments projected by your Committee are still proceeding, and it is possible that these may finally lead to minor modifications in the curves, in which case your Committee will present a new set of curves to take the place of those now offered.

PAGE 8

PAR. 12. IN THE SECOND LINE OF PAR. 12, CHANGE THE WORD "AT" TO "FOR."

PAGE 10

PAR. 22. CHANGE FIRST LINE OF TABULATED MATTER IN ORIGINAL PAR. 22 TO READ AS FOLLOWS:

> Diameters 1 in. or over but less than 2½ in. ... No. 13 B. W. G.

CHANGE THE TWO LINES FOLLOWING THE TABULATED MATTER TO READ:

> For each increase of one gage in thickness the maximum allowable working pressure will be increased by 200 lb. divided by the diameter of the tube in inches.

PAGE 12

PAR. 28. DIRECTLY AFTER SECTION *a* IN ORIGINAL PAR. 28, ADD:

b Should the above rule for minimum allowable elongation give a value of less than 24 per cent for firebox steel, the minimum allowable elongation shall be taken as 24 per cent, subject to the modification given in Par. 29.

CHANGE SECTION *b* TO SECTION *c* AND SECTION *c* TO SECTION *d*.

PAR. 31. ALLOW THIS PARAGRAPH TO STAND AS IT APPEARS IN THE PRESENT EDITION OF THE CODE (EDITION OF 1914), CANCELING ALL REVISIONS PROPOSED.

PAGE 44

PAR. 182. CHANGE PAR. 182 TO READ AS FOLLOWS:

182 The distance between the center lines of any two adjacent rows of rivets, or the "back-pitch" measured at right angles to the direction of the joint, shall have the following minimum values:

a If $\frac{P}{D}$ is 4 or less, the minimum value shall be 2 D;

b If $\frac{P}{D}$ is over 4, the minimum value shall be

$$\left[2 + 0.1\left(\frac{P}{D} - 4\right)\right] D$$

where P = pitch of rivets in longitudinal rows where a rivet in the inner row comes midway between two rivets in the outer row,

D = pitch of rivets in the outer row less pitch of rivets in the inner row where two rivets in the inner row come between two rivets in the outer row. (It is here assumed that the joints are of the usual construction where the rivets in any single row are evenly spaced.)

PAR. 184. IN SECTION *c* OF PAR. 184 INSERT AFTER THE FIRST WORD "IN" IN THE FIRST LINE THE FOLLOWING WORDS:

"the portion of"

IN THE SECOND LINE AFTER THE WORD "BOILERS" INSERT THE FOLLOWING:

"exposed to the products of combustion,"

PAGE 47

PAR. 193. CHANGE PAR. 193 TO READ AS FOLLOWS:

193 When a shell or drum is drilled for tube holes in the line diagonal with the axis of the shell or drum, as shown in Fig. 12, the efficiency of the ligament between the tube holes shall be that given by the diagram, Fig. 12*a*.

In this diagram the abscissae are $\frac{p}{d}$ and the ordinates $\frac{p'}{p}$, where

p = longitudinal pitch of tube holes, or distance between centers of tubes in a longitudinal row, in.
p' = diagonal pitch of tube holes, in.
d = diameter of tube holes, in.

To use the diagram, Fig. 12*a*, the values of $\frac{p}{d}$ and $\frac{p'}{p}$ are computed and the efficiency for the corresponding point is read off from the diagram. Should the point fall above the curve of equal efficiency for the diagonal and longitudinal ligaments, the longitudinal ligament will be the weaker, in which case the efficiency is computed from the following formula:

a $\qquad \frac{p - d}{p}$

Examples: 1st, diagonal pitch of tube holes in drum as shown in Fig. 12 = 6.42 in.
Diameters of holes = 4 1/32 in.
Longitudinal pitch of tube holes = 11½ in.

$$\frac{p}{d} = \frac{11.5}{4.031} = 2.853$$

$$\frac{p'}{p} = \frac{6.42}{11.5} = 0.558$$

The point corresponding to these values is shown at *A* on the diagram, Fig. 12*a*, and the corresponding efficiency is 36.3 per cent. As the point falls below the curve of equal efficiency for the diagonal and longitudinal ligaments, the longitudinal ligament is the weaker.

2d, diagonal pitch of tube holes in drum = 6 35/64 in.
Diameter of tube holes = 4 1/64 in.
Longitudinal pitch of tube holes = 7 in.

$$\frac{p}{d} = \frac{7}{4.0156} = 1.743$$

$$\frac{p'}{p} = \frac{6.547}{7} = 0.935$$

The point corresponding to these values is shown at *B*, and it will be seen that it falls above the line of equal

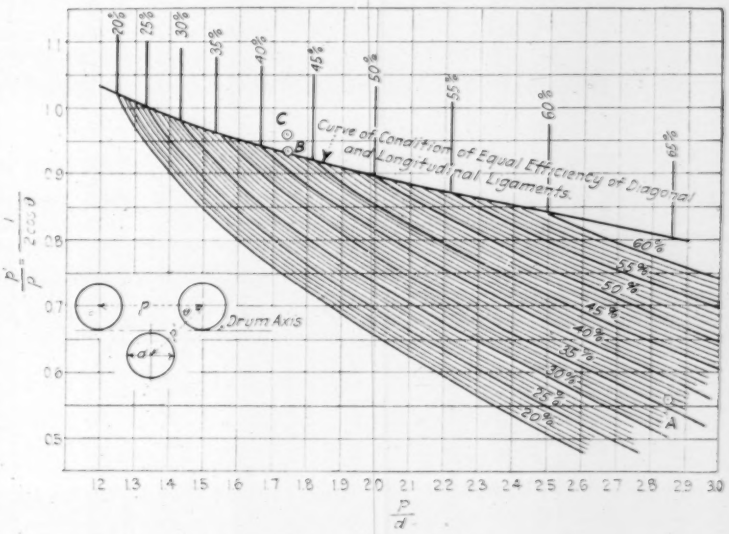


FIG. 12*a*

efficiency for the diagonal and longitudinal ligaments, in which case the efficiency is computed from formula *a*. Applying formula *a*, we have

$\frac{7 - 4.0156}{7} = 0.426$, efficiency of ligament, or 42.6 per cent.

PAGE 48

PAR. 194. IN ADDITION TO THE REVISION PROPOSED IN THE MARCH SCHEDULE, ADD AT THE END OF PAR. 194 A NEW PARAGRAPH TO READ AS FOLLOWS:

Flanges of domes shall be formed with a corner radius measured on the inside, of at least twice the thickness of the plate for plates 1 in. thick or less, and at least three times the thickness of the plate for plates over 1 in. in thickness.

PAGE 50

PAR. 200. IN THE EIGHTH LINE CHANGE THE WORD "OR" AFTER "DRILLING" TO "OF."

PAGE 51

PAR. 203. IN SECTION *a* OF PAR. 203 IN THE FOURTH LINE, REPLACE THE WORDS "BY THE FORMULA" BY THE WORD "AS."

PAGE 52

PAR. 212. IN SECTION *c* OF PAR. 212, IN THE FIRST LINE, OMIT THE WORD "INTERNAL."

IN THE LAST LINE OF SECTION *c*, WHICH IS THE LAST LINE OF PAR. 212, OMIT THE LETTER "R."

PAGE 53

PAR. 214. IN THE FIFTH LINE OF PAR. 214 CHANGE THE WORD "SHALL" TO "MAY," AND IN THE SIXTH LINE OMIT THE WORDS, "BUT NOT LESS THAN 3 IN."

PAGE 54

TABLE 4. IN THE SECOND LINE UNDER ITEM *c* CHANGE "*c*" TO "*b*."

PAR. 220. IN SECTION *c* OF PAR. 220 IN THE THIRD LINE INSERT THE WORD "AS" BEFORE "GIVEN."

PAGE 61

PAR. 239. IN THE NEW PARAGRAPH WHICH IS PROPOSED IN THE MARCH SCHEDULE TO PRECEDE THE EXAMPLE, CHANGE THE WORDS "BUTT AND STRAP CONSTRUCTION" TO "BUTT AND SINGLE OR DOUBLE STRAP CONSTRUCTION."

PAGE 69

PAR. 274. IN THE FIFTEENTH LINE AFTER THE WORD "NUMBER" INSERT "AND SIZE."

PAGE 75

PAR. 296. IN THE FIRST LINE OF THE PROPOSED ADDITION TO PAR. 296, WHICH APPEARS IN THE MARCH JOURNAL, INSERT THE FOLLOWING AFTER THE WORD "NECESSARY":

> an exception may be made to the rule that the gage must be arranged so that it cannot be shut off except by a cock placed near the gage and

PAGE 76

PAR. 299. IN THE SEVENTH LINE, CHANGE THE SENTENCE FOLLOWING THE WORD "FACE" TO READ AS FOLLOWS:

> See Par. 12 for exceptions. For pressures above 160 lb. per sq. in., cast iron shall not be used for boiler pressure parts except for fittings under 2 in. pipe size or equivalent cross sectional area. See Pars. 9 and 245.

FIG. 18*a*. OMIT THE CAPTIONS, "BRONZE OR STEEL" AND "WROUGHT IRON."

PAGE 79

PAR. 332. INSERT A SENTENCE AT THE BEGINNING OF PAR. 332 TO READ AS FOLLOWS:

> 332 Each boiler shall conform in every detail to these Rules, and shall be distinctly stamped with the symbol shown in Fig. 19, denoting that the boiler was constructed in accordance therewith.

IN THE EIGHTH LINE OF THE REVISION OF PAR. 332 APPEARING IN THE MARCH JOURNAL, AFTER THE WORD "AND" INSERT THE WORD "HE."

REPLACE THE FIRST TWO SENTENCES OF THE SECOND PARAGRAPH OF PAR. 332 BY THE FOLLOWING:

> Each boiler shall be stamped below the symbol as follows, with intervals of about one-half inch between the lines:
>
> 1. Name of state in which the boiler is built
> 2. State serial number of the boiler
> 3. Name of the manufacturer (and manufacturer's serial number if desired)
> 4. Installation number and name of the state in which the boiler is installed
> 5. Year put into service.
>
> Items 1, 2 and 3 are to be stamped at the shop where built.
>
> Items 4 and 5 are to be stamped by the proper authority at point of installation.

PAGE 80

FIG. 20. REVISE FIG. 20 TO READ AS FOLLOWS:

To be stamped at shop where built:

(State in which boiler is built) ..... STD
(State serial number of boiler)
(Name of mfr.) (Mfr.'s serial No.)

To be stamped in field:

(Installation No.) (Name of state)
(Year put into service)

PAGE 83

PAR. 354. OMIT SECTION *b* OF PAR. 354.

PAGE 85

PAR. 361. IN THE NINTH LINE INSERT THE WORD "PIPE" BEFORE "CONNECTIONS."

PAGE 101

PAR. 416. OMIT PAR. 416, AND FIGS. 26 AND 27.

In accordance with its plan in eliminating as far as possible preventable diseases among workers in various industries, the United States Public Health Service of the Treasury Department has begun an investigation of the effect on the health of workers of pneumatic hammers as used in cutting limestone. Workers in this industry who use air hammers experience a temporary numbness of the fingers whenever the hand becomes chilled. The causes appear to be the higher vibration rate of the hammers when used in soft stone, and the tight and strained grasp which the workers have to use. Cold weather brings out the symptoms, but is not of itself a cause of the condition. By using a shank of larger diameter, which permits a more comfortable grasp by the worker, it is believed that a good deal of the strain on the muscles will be relieved. If the shank were enlarged by using a tight-fitting covering of asbestos, or some similar substance, the cold would not be intensified by the metal as at present and the handle would act as a shock absorber. (*Official Bulletin*, March 28, 1918, p. 4)

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, Its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

THE Secretary's letter this month might well be entitled, The Usefulness of a Technical Society in War. Notwithstanding that what follows is a routine activity, nevertheless, the Secretary doubts if many know of it. Our great ambition is to have the Society used.

Below is given a digest of only a few of the inquiries which were received in one week last month, accompanied by abstracts of the replies made and some typical letters of appreciation for our attention. Sometimes the information is secured by telephone, sometimes the inquiries are referred to the faithful members of the Society closest to hand, but when the urgency is not too great they are sent to committees to insure the replies' being of the most authoritative nature possible.

Your Secretary believes that the sum total of this prompt individual service is the best means of making the Society useful, and he is accordingly devoting special attention to such service, giving priority obviously to requests which are of a war nature.

One of the inquiries in this period was from a Government department for the names of manufacturers to make carpenters' stoppers, which was a somewhat unusual request, but regarding which we were able to secure considerable information through the courtesy of a member of the Society outside of New York and which we forwarded within five days.

Another, from a Government arsenal, was for information regarding a special type of gas mask for industrial use. This, like the foregoing inquiry, was a matter of urgency, so that the arsenal "might get immediate relief." We were able to supply this information within four days.

Still another inquiry from a Government department requested "at the earliest possible time" information regarding remedying a certain trouble with the machinery on a transport. This again was a matter which required us to get in touch with a member who had had special experience. We fortunately were able to and furnished the information the same day.

Another request was from a member for comprehensive information to assist him to prepare an important paper, as follows:

"If there are any permanent changes brought about by the war which necessitate greater activities in engineering research, what are these changes?

"How can the difficulties after the war be lessened by activities in research?

"What important engineering-research problems were brought about by the war and which can be published without injuring our interests?

"What phases of engineering research should be taken up at the present time?

"What engineering problems will be of utmost value to us during the reconstruction period?"

By referring this inquiry to our Research Committee, the member was able to secure valuable replies.

Also in this same week inquiries were received on such varied subjects as catalogues for aviation repair depots, to be used in the preparation of requisitions on purchase orders; sizes of gaskets for standard and extra heavy flanges running from 20-in. to 60-in. pipe: all the recent articles relating to concrete-ship construction, soot cleaners, pulverized coal, small high-power water motors for experimental purposes, hardening of forgings of 0.40 to 0.50 carbon steel, baling presses, replacing a worn-out laboratory steam engine, motor-driven turbine blowers for a forced-draft proposition, etc. Some of these were answered direct by the Secretary or Editor assisted by our own extensive files and indexes, and some were referred to the Library Service Bureau, which every member should remember has special facilities for making bibliographical searches on all technical subjects.

Another set of numerous inquiries demanding urgent and special attention the same week were requests from Government departments and industries engaged in war work for men possessing special qualifications, to be commissioned or to serve in civilian capacities.

In this class came a request for nominations of specially qualified professional engineers for submarine duty, a request from an important Government board for men of the highest attainment in projectile fuses; a request for a whole staff of both technically trained and experienced engineers for officers or civilians in the construction and later the operation of nitrate and powder plants, a request for 75 men qualified for steel inspectors, and so on. We have furnished the names of several hundred specialists in one day and since our bureau was started have supplied over 3000 names. The members have responded splendidly to the request to fill out classification blanks, with the result that we are told that we have the most complete bureau in the United States.

On the other hand, we have on the average of three offers a day from members who desire to give their personal services or who have manufacturing facilities which they can devote to the service of the Government, and we make it our business to give prompt attention to these requests and refer them to the most likely departments requiring such services. The Engineering Council hopes soon to act as a clearing house for all the societies in the matter of providing men with special experience to fill particular positions in or out of the Government service.

In acknowledgment of our services we receive some very nice letters. In one recent acknowledgment they wrote: "Once more we are very grateful to you for your splendid work in submitting names of men for——"

We recently had a comprehensive request from the American Library Association to send our JOURNAL to the forty or more U. S. cantonment camps for the duration of the war. Upon the approval of the Library Committee this was promptly complied with, and the letters of acknowledgment we received afford wholesome reading. One camp librarian writes: "It is the heartiest sort of thanks that we extend to the Society for its complimentary subscription to its JOURNAL. Our table of technical periodicals is a mighty well patronized institution, and most welcome to it is your JOURNAL."

The Gage Committee has secured a signal triumph. Under its initiative the Society arranged a conference in Washington of the heads of all technical Government bureaus and made

the proposition developed at the Cincinnati meeting to have all gages certified in one place. The Bureau of Standards was designated by common consent as the place. Included in the Gage Committee's recommendation was the establishment of branch certification. We have the satisfaction of reporting the success of the certification and the establishment of a branch in New York and in the Engineering Societies Building.

The object of these reports is not, however, to produce a sense of satisfaction over performance however well accomplished. Rather we should be inspired to greater undertakings commensurate with our special abilities.

The Lord tells of some who had ten talents, some had five talents and of the man with one talent who did nothing even with his one talent!

In which group shall engineers place themselves?

There is only one way we can double our talents, namely, by using them. This nation has thrown itself unselfishly into the war. Write in to the Secretary what you can do more than you are doing, and what manufacturing facilities you have to offer. Also suggest more things that the Society can do. Come to the Spring Meeting in Worcester, June 4 to 7, and inspire all to greater endeavor.

CALVIN W. RICE,
Secretary.

Council Notes[1]

AT the meeting of the Council on March 15 the following members were present: C. H. Benjamin, *Vice-President,* in the chair, John H. Barr, W. F. M. Goss, R. H. Fernald, F. N. Bushnell, F. R. Hutton, A. M. Greene, Jr., D. S. Jacobus, Wm. H. Wiley, *Treasurer,* and Calvin W. Rice, *Secretary.*

Boiler Code Committee. Interpretations of the Boiler Code in cases Nos. 175, 185 and 186 were approved with slight modification and ordered printed.

War Activities Committees. The Secretary reported the following committees of the Society and joint committees on which the Society is represented, as being engaged in war activities:

Committee on Engineering Resources
Engineering Service Committee of the Engineering Council
Committee on Vocational Training
Committee on Machine Shop Practice
National Defense Committee
Gage Committee
Naval Consulting Board of the United States
National Research Council
New York Military Engineering Committee.

Communications. A letter was read from Sir J. A. F. Aspinall, Honorary Member of the Society, announcing his election to the presidency of the Institution of Civil Engineers, and it was voted to extend congratulations and greetings to Sir John. The letter also mentioned the visit of Messrs. Hartness and Durand from our Society to the London Aircraft Standards Conference.

Adjournment was taken to meet in Philadelphia on April 23 on the invitation of the Philadelphia Local Committee, and to join with the Philadelphia Section at their regular meeting on this date. Following is the program arranged for the Council on this occasion:

9.00 a. m. Council leave by motor car for Hog Island, guests of Resident Engineer, H. H. Esselstyn, member of the Publication Committee.

11.30 a. m. Council leave Hog Island by boat, as guests of Director of Bureau of Wharves and Docks, George S. Webster, for a trip up the river to Cramp's Shipyard.

12.15 p. m. Luncheon at Cramp's Shipyard, guests of L. F. Moody, Secretary of the Philadelphia Section.

1.15 p. m. Leave Cramp's Shipyard by automobile.

2.00 p. m. Council Meeting at Adelphia Hotel.

7.00 p. m. Dinner with the Philadelphia Section at Adelphia Hotel.

CALVIN W. RICE,
Secretary.

[1] The April JOURNAL went to press before the Council Meeting.

The Engineering Council's War Committee of Technical Societies

THE War Committee of Technical Societies, of which Mr. David W. Brunton is chairman, was founded by the Engineering Council in July, 1917, and represented at the time of its formation the four founder societies. The Committee was formed for the purpose of stimulating members of the various technical societies into giving consideration to the matter of the invention of war apparatus, with the object of assisting the Army and Navy. As a definite means of effecting this object, the Committee was given the work of procuring problems—especially difficult problems—from the Army and Navy for presentation to the membership of the societies for solution.

For several months the Committee has been coöperating actively with the Naval Consulting Board, and now has offices and a meeting room in the New York office of the Naval Consulting Board, 15 Park Row. The Committee now has the following membership:

American Society of Civil Engineers:
Nelson P. Lewis, Major James M. Boyle
American Institute of Electrical Engineers:
Harold W. Buck, A. S. McAllister
American Society of Mechanical Engineers:
A. M. Greene, Jr., R. N. Inglis
American Institute of Mining Engineers:
David W. Brunton, Edmund B. Kirby
American Gas Institute:
Dana D. Barnum, E. C. Uhlig
American Electrochemical Society:
Joseph Bijur, Dr. Chas. A. Doremus
Illuminating Engineering Society:
Louis B. Marks, Preston S. Millar
Mining and Metallurgical Society of America:
Christopher R. Corning, George C. Stone
American Society of Refrigerating Engineers:
Henry Torrance, F. E. Matthews
American Institute of Chemical Engineers:
Charles F. McKenna, Frank E. Dodge
American Chemical Society: (Coöperating)
Dr. Chas. Baskerville, W. D. Richardson

For the past several months the Committee has been working energetically along these lines and has received from governmental departments problems of importance which have been passed on to various trained specialists, and in many cases information of great value has been received and turned over to the Government. Also through this Committee many of the largest and most important experimental and research laboratories of the country have offered their services to the Government and are now carrying on experimental work for the Government, which work has been apportioned to them by the Committee.

In connection with the above the Committee is now super-

intending tests and experiments for various departments of the Army.

One of the most pleasing features of the work in this connection has been the exhibition of intense interest and energy on the part of the various specialists in making tests and experiments for the Government. These men and these laboratories have given freely of their services for this purpose without any cost whatever, and have rendered services which would have cost the Government under ordinary circumstances large sums of money.

The value of the work of this Committee is now so well recognized that a prominent Ordnance officer has been assigned to the War Committee, so that complete and continuous contact may be effected with the Ordnance Department.

Another and most important function of the Committee is to assist members of the technical societies to develop their inventions, and to bring these inventions to the attention of the proper governmental authorities so that valuable inventions may be made effective in the shortest possible time. On account of the connection of this Committee with the Naval Consulting Board, abundant funds are available for testing out any idea or invention which appears to be promising.

On account of the fact that additional technical societies are now represented on the Committee over and above the four founder societies, the Committee now represents technical societies having a total membership of approximately 45,000 technically trained men, distributed as follows:

American Society of Civil Engineers	8600
American Institute of Electrical Engineers	7525
American Society of Mechanical Engineers	8800
American Institute of Mining Engineers	5500
American Gas Institute	1600
American Electrochemical Society	1600
Illuminating Engineering Society	1250
Mining and Metallurgical Society of America	310
American Society of Refrigerating Engineers	410
American Institute of Chemical Engineers	300
American Chemical Society (Coöperating)	9000

R. N. INGLIS.

Special Service by the Journal

Arrangements have been made whereby THE JOURNAL of our Society is to render a special engineering-data service to the recently organized Research Information Committee of the National Research Council.

The purpose of this committee, as announced in the April number, is to gather and distribute to the various departments of the Government technical and scientific information, the results of investigation and research, and confidential advice from all available sources. The committee has headquarters in the rooms of the National Research Council, 1023 Sixteenth Street, Washington, and branch offices at the American Embassies in London and Paris. The technical adviser of the committee at the central office in Washington is Dr. Graham Edgar, formerly professor of chemistry at the University of Virginia.

The service which THE JOURNAL is rendering has developed as a result of the review of engineering periodicals which it has published for several years, and for the conduct of which a department has been built up at Society headquarters for scanning and reviewing the periodicals which come to the library from all parts of the globe. Abstracts are made of important articles appearing in journals of all languages, for publication in THE JOURNAL of the A.S.M.E., and copies of these are transmitted to Washington, together with more extended abstracts when required, translations of special articles, photostatic prints of articles and engravings, lists of titles appearing in the technical press, etc., as may be necessary to meet the demands of the Research Information Committee and the Government departments which it serves.

Power-Plant Inspection

The United States Fuel Administration have advised us that they are about to take a census of the power plants of the country with a view to listing principally information regarding their equipment and methods of operation. They state that the census will be similar to that taken by the Committee on Industrial Preparedness of the Industrial Plants of the Nation, and similarly will cover all the states of the Union. It is planned that the inspections shall be repeated at approximately regular intervals of several months each. The work will be done under the supervision of each state. As the Society coöperated in this previous work, it has been requested to offer similar service to the Fuel Administration for the new census. The census taking will consist in filling in on special forms, which will be provided, certain data called for.

If all will coöperate, such work can be done at the expense of only a fraction of the time of each member. *Volunteers* for such service are requested to communicate with the Society immediately for further information.

John Fritz Medal for J. Waldo Smith

On Wednesday, April 17, the John Fritz Medal was awarded to J. Waldo Smith, Mem.Am.Soc.M.E., chief engineer of the Board of Water Supply, New York, for "achievement as engineer in providing the City of New York with a supply of water" as a result of the construction of the Catskill Aqueduct. The meeting for the award was held in the Engineering Societies Building. The presentation was made by Ambrose Swasey, Past-President Am.Soc.M.E., who told Mr. Smith that he had accomplished one of the most remarkable engineering feats in history. In accepting, Mr. Smith praised his associates and subordinates, and said they had enabled this work to be accomplished by aiding in every problem which arose.

Encouraging Report from Major Gilbreth

Many inquiries have been received at Society headquarters regarding the health of Frank B. Gilbreth, who was taken critically ill while in the service at Fort Sill, Oklahoma. It is a pleasure to report that Major Gilbreth has so far recovered that he has been able to make the journey to Washington, D. C., where he will remain for several weeks in the Walter Reed hospital to receive treatment for rheumatism. Mrs. Gilbreth advises that as soon as his health has improved to the point where he can have "sick leave" he will return to his home at Providence, R. I., for final convalescence.

Opportunity for A.S.M.E. Women

The Woman's Auxiliary of the American Institute of Mining Engineers now has headquarters in the ladies' reception room on the ground floor of the Engineering Societies Building, New York. This will be used as a war-relief work room for the preparation of comforts for the engineer regiments. The members of the Woman's Auxiliary will be glad to have any of the ladies of the families interested in The American Society of Mechanical Engineers call at the headquarters and join with them in the very helpful work which they are undertaking.

SPRING MEETING PROGRAM

Tuesday, June 4

10:00 a. m. Opening of headquarters and registration at Hotel Bancroft
12:30 p. m. Luncheon for Sections Delegates and Council
2:00 p. m. Council Meeting
2:00 p. m. Meeting of Research Committee and Flow Meters Sub-Committee
8:00 p. m. Addresses of Welcome by Mayor Pehr G. Holmes, Past-President Ira N. Hollis, and R. Sanford Riley, President, Worcester Chamber of Commerce. (*Hotel Bancroft*)
Address by Charles G. Washburn on The Growth of an Industrial City
Reception and Dance

Wednesday, June 5, New England Day

10:00 a. m. Business Meeting (*Worcester Polytechnic Institute*)

FIRST NEW ENGLAND SESSION

The Small-Industry in a Democracy, George H. Haynes
The Textile Industry in Relation to the War, J. E. Rousmaniere

10:30 a. m. Visit to Crompton and Knowles Loom Works. Special invitation to ladies
12:30 p. m. Buffet Luncheon (*Polytechnic Institute*)
1:00 p. m. Visit to plant of Royal Worcester Corset Company. Luncheon served. Special invitation to ladies
2:00 p. m. Sections Conference
2:00 p. m. Simultaneous Sessions (*Polytechnic Institute*)

SECOND NEW ENGLAND SESSION

Papers will be presented upon subjects relating to New England's industries under war conditions, including: Converting a Factory for Munitions Manufacture; Fire Protection; Training Labor for Shipbuilding; Oil Fuel in New England Power Plants

GENERAL SESSION

Foundry Cost and Accounting System, W. W. Bird
The Public Interest as the Bed Rock of Professional Practice, Morris L. Cooke
Moisture Reabsorption of Air-Dried Douglas Fir and Hard Pine, and the Effect on the Compressive Strengths, Irving H. Cowdrey
A High-Speed Air and Gas Washer, Lieut. J. L. Alden
Investigation of the Uses of Steam in the Canning Industry, J. C. Smallwood

INDUSTRIAL SAFETY AND WORKMEN'S COMPENSATION SESSION

This session will be in charge of the Sub-Committee on Protection of Industrial Workers

4:00 p. m. Tea and Reception at Tatnuck Country Club
8:15 p. m. General War Session. (*Hotel Bancroft*)

The general theme of this session will be: How the Engineering Societies Can Assist in the Procurement Program of the Government. Some major topics to be discussed are: Ordnance and Ships for the Navy Department; Munitions for the Army; Aircraft Material

Thursday, June 6

10:00 a. m. Simultaneous Sessions (*Worcester Polytechnic Institute*)

GENERAL SESSION

Efficiency of Gear Drives, C. M. Allen and F. W. Roys
Self-Adjusting Spring-Thrust Bearing, H. G. Reist
Air Propulsion, Morgan Brooks
The Elastic Indentation of Steel Balls under Pressure, C. A. Briggs, W. C. Chapin, H. G. Heil
Electric Heating of Molds, Harold E. White
Stresses in Machines When Starting or Stopping, F. Hymans
(To be read by title only)

FUEL SESSION

An Investigation of the Fuel Problem in the Middle West, A. A. Potter
Topical Discussion on Fuel Economy. (Arranged for by the Fuel Conservation Committee of the Engineering Council)

VOCATIONAL TRAINING SESSION

A discussion of The Boston System for Vocational Training

1:00 p. m. Luncheon (*Norton Company's Plant*)
2:30 p. m. Paper upon the results of a questionnaire upon housing, issued to leading industrial firms
4:00 p. m. Inspection of the Norton Company's community housing and garden projects
7:00 p. m. Dinner (*Worcester Country Club*)
8:30 p. m. Illustrated Lecture. Harvard's Contribution to Astronomy, Dr. S. I. Bailey. Dancing

Friday, June 7

9:00 a. m. Automobile Trip to Camp Devens, via Clinton Dam; Lunch at Camp Devens; Continuation of Trip to Concord and Lexington and return via the Wayside Inn

FEATURES OF THE SPRING MEETING

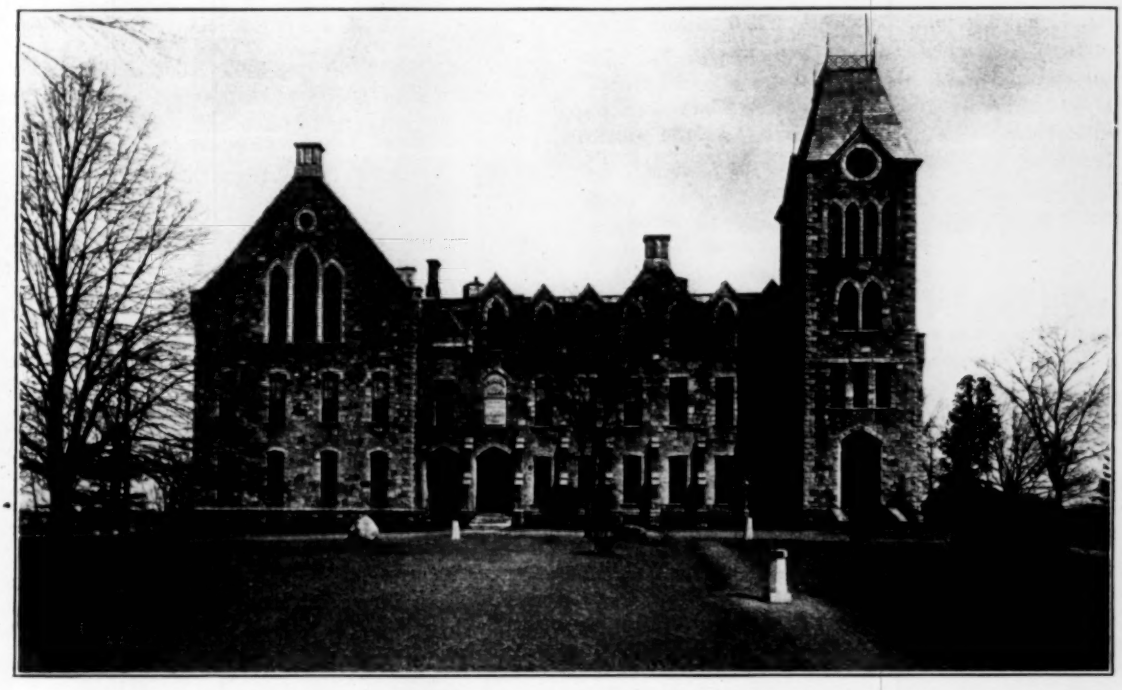
Worcester, Mass., June 4 to 7, 1918

THE coming Spring Meeting, like the two previous meetings, will be primarily a convention for conference on war problems, to which the engineers of the country, almost as a unit, are now giving their thought and attention.

It has been the usual custom at these Spring Meetings to have one or more sessions under the direction of the engineers in the city where the meeting is held, but in this instance the scope of the local representation has been broadened, and one whole day will be given over to the several the country. Besides these special features, there will be two general sessions for the presentation of technical papers.

Entertainment Features

This is to be an outdoor convention with every opportunity for enjoyment of the natural beauty of the New England country, by means of automobile trips and entertainment at two country clubs at Worcester. Tea will be served on Wednesday afternoon at the Tatnuck Country Club, and on Thursday evening there will be a dinner at the Worcester Country Club, followed by a lecture by Dr. S. I. Bailey on Harvard's Contribution to Astronomy.



Boynton Hall, Worcester Polytechnic Institute, Containing the Offices of the President. Several Sessions will be held at the Institute, where all Memeers will be Welcomed

Local Sections of the Society in New England, and the Providence Engineering Society, with papers on the work of the industries of New England in connection with the war.

On the evening of the same day, Wednesday, June 5, there will be a session, with addresses by representatives of the United States Government, on How the Engineering Societies Can Assist the Procurement Program of the Government in respect to ordnance, aircraft, ships, mobilization of labor, quartermasters' supplies, etc. On Thursday there will be a topical discussion on Economy in the Use of Fuel, arranged by the Fuel Conservation Committee of the Engineering Council, which will present the consensus of the experience of many of the fuel engineers of the country to whom questionnaires have been sent asking for definite data. Another session pertinent to the times will relate to vocational training, based on the Boston system, at the four principal technical schools of that city, under the direction of the War Department. Five hundred men are to be trained at Wentworth Institute and large numbers at the other schools.

On the afternoon of Thursday there will be an inspection of the model community for workmen of the Norton Company, at Worcester, with a discussion of housing problems based on a questionnaire issued to a large number of firms throughout

Two excursions have been planned for Wednesday, with special thought for the ladies' entertainment, though members and guests are cordially invited. The first of these trips is a visit in the morning to the Crompton and Knowles Loom Works, where their weave room and factory will be inspected and their many interesting and fancy looms shown in operation. The plant of the Royal Worcester Corset Company will be the scene of the afternoon's activities. After luncheon, at the plant, an inspection trip will be made to see how the Royal Worcester corsets are manufactured.

The various professional sessions will be so disposed that all day Friday will be free for automobiling, when a trip is planned to the cantonment at Camp Devens where lunch will be served; after which the trip will be continued to Concord, Lexington, and return by Wayside Inn.

Delegations from Nearby Cities

It is already arranged for delegations to attend from Boston, Providence and New York, and in the latter city a special

committee has been appointed which expects the attendance of as many as 400 from New York and nearby points, representative of the New York membership. It is suggested that any who can do so should go to Worcester by automobile, and for the benefit of such the following instructions have been issued:

AUTOMOBILE ROUTES TO WORCESTER

From New York to Worcester take the main-traveled road to New Haven, 75 miles from Columbus Circle, New York. The route from New Haven leads to Hartford, Conn., by two roads: One through Middletown, 40.9 miles, which gives better views than the alternative route through Meriden, which is 37.1 miles. From Hartford the route goes to Springfield by Suffield, 26.9 miles; and from Springfield to Worcester the route is by Palmer, 51 miles, a total distance of 155.9 miles. Lunch can be secured at the Hotel Taft in New Haven, or at the Highland Court Hotel in Hartford, Conn.

From Albany to Worcester the route is from Albany to Troy, 8 miles, then to Williamstown, 36 miles, and from Williamstown over the Mohawk Trail to Greenfield, 42 miles; from there to Gardner, 39.4 miles, and then to Worcester, 28.2 miles, a total distance of 153.6 miles. A shorter route is from Albany to Pittsfield, 36 miles, then to Springfield, 56 miles, and from Springfield to Worcester, 51 miles, a total distance of 143 miles. However, the beauty of the shorter route is not to be compared with that of the other.

For Points West of Albany to Worcester the route will be shortened somewhat by turning off at Schenectady, going direct to Troy rather than to Albany.

Fred S. Sly, member of the Attendance Committee of New York, care of the *American Architect*, 243 West 39th Street, New York, will be glad to secure any special information for tourists that may be desired, or inquiries can be addressed to the Touring Bureau of the Automobile Blue Book Publishing Company, 243 West 39th Street, New York.

HOTELS AT WORCESTER

The headquarters for the convention will be at the Hotel Bancroft, and any who go by automobile are asked to call at the headquarters before putting up their cars so that they may be informed as to the garage which can best serve them at the time they call.

The leading modern hotels of Worcester are the Bancroft and the Warren. The minimum rates for these are as follows:

	Without Bath		With Bath	
	Single	Double	Single	Double
Bancroft	....	....	$2.75	$5.00
				6.00
				7.00
Warren	$1.50	$2.50	2.00	3.50

Other hotels, all of which have moderate rates, are the Bay State House, Franklin, New City, New Park and Pleasant.

Every person expecting to attend should secure his rooms well in advance, since hotels in Worcester, as in other cities influenced by the business of the war, are having a large patronage and usually are crowded.

While the Registration and Information Bureaus will be located at the Bancroft, several of the professional sessions will be held at the Worcester Polytechnic Institute, which will, in a measure, serve as a second headquarters where all will be welcome and where everyone in attendance is requested to make himself at home.

Fuel Session at Spring Meeting

As announced in the April JOURNAL, on Thursday morning, June 6, there will be a session of the Spring Meeting at the Worcester Polytechnic Institute for five-minute presentations of data relating to fuel economy. This session has been planned by the Fuel Conservation Committee of the Engineering Council to assist the United States Fuel Administrator in his nation-wide campaign for fuel economy. Discussion is solicited upon the topics listed below, and all those who have studied the problems incident to the adverse fuel conditions of the past winter are invited to give the results of their experience in the form of brief written communications of from 100 to 1000 words each.

1 WHAT ARE THE ECONOMIC EFFECTS OF IMPURITIES IN COAL?
Incombustible in fuel has a detrimental effect upon furnace operation out of all proportion to the percentage of refuse contained. It has been claimed that when coal contains 40 per cent of refuse it becomes valueless as fuel. Recent conditions have afforded opportunities for interesting observations in this connection. What has been your experience?

2 TO WHAT EXTENT IS FUEL OIL LIKELY TO BE USED AS A SUBSTITUTE FOR COAL?
Information is desired as to present use, advantage found, probable available supply, etc.

3 HOW CAN SOFT COAL BE BURNED WITHOUT SMOKE IN MARINE BOILERS?
The avoidance of smoke would decrease the radius of visibility of our ocean carriers by many miles and greatly reduce their liability to attack by submarines. If efficiency is improved incidentally it means much more than the mere coal saving.

4 WHAT ARE THE POSSIBILITIES IN THE DIRECTION OF THE UTILIZATION OF ANTHRACITE WASTES?
What success have you had in burning anthracite slack or culm? Do you mix it with soft coal, and in what proportions? What sort of grate do you use and what is your practice with regard to thickness of fire, draft, rate of combustion? Can the mixture be burned in a stoker?

5. WHAT INSTRUMENTS ARE USEFUL AND DESIRABLE IN THE BOILER ROOM AS AIDS IN SAVING COAL?
What class of equipment has been of the most value to you and how?

6 WHAT IS ESSENTIAL TO THE ECONOMICAL OPERATION OF HAND-FIRED BOILER FURNACES WHEN USING SOFT COAL?
Helpful hints as to firing methods, front or side; frequency of firing; management of dampers; cleaning; etc.

7 TO WHAT KINDS OF PLANTS AND COALS ARE THE DIFFERENT TYPES OF MECHANICAL STOKERS RESPECTIVELY ADAPTED, AND WHAT IS THE LIMITING FACTOR TO THEIR USE IN THE SMALL PLANT?
Can we agree upon the type of fuel to the combustion of which each type of stoker is best adapted? How large must a plant be to warrant the use of a mechanical stoker?

8 WHAT EXPERIENCE HAVE YOU HAD IN THE USE OF WOOD AS FUEL? TO WHAT EXTENT IS WOOD AVAILABLE AS A FUEL?
The coal shortage has occasioned the use of wood fuel in many unwonted places. Accounts of experience that will be helpful are solicited.

9 WHAT COAL ECONOMIES CAN BE EFFECTED IN RESIDENCE HEATING?
He who could make one ton of coal do the work of two during the past winter, not only conserved the coal for his neighbor and saved his own money but was comfortable when he might have otherwise been cold. How can it be done?

10 WHAT COAL ECONOMIES CAN BE EFFECTED IN THE SMALL STEAM PLANTS?
Plants which are not sufficiently important departments of their industries to warrant expert supervision and are too small to support real engineers waste a lot of coal and steam in the aggregate. What are the principal sources and methods of waste and how can they be avoided and corrected?

11 WHAT EXPERIENCES HAVE YOU HAD WITH THE STORAGE OF COAL?

AMONG THE LOCAL SECTIONS

THE semi-annual conference of Sections' representatives will take place during the Spring Meeting at Worcester. The members of the Council will meet at luncheon with the Sections' delegates, and addresses will be made by President Main and Dr. Hollis.

The Council made its second visit to a Section on April 23, when it held its April meeting at Philadelphia, and in the evening attended the meeting of the Philadelphia Section. During the forenoon the members of the Council had an opportunity to make a special inspection of Hog Island.

Secretary Rice is to go on a somewhat extended trip which will take him to a large number of the Sections. Coming during this crisis in the history of our country, it is felt that this visit by the Secretary will do an inestimable amount of good in correlating the war activities of the Society through the medium of its Sections.

A noteworthy example of the effectiveness of coöperation between Sections and Student Branches was had at New York on April 9. The New York Section turned its April meeting over to the Metropolitan Student Branches located at Columbia University, New York University, Polytechnic Institute of Brooklyn, and Stevens Institute of Technology. Two sessions were held and a buffet supper served between them. About 300 persons attended the afternoon session, over 400 partook of the supper and over 650 were present in the evening. The program included eight speakers, the supper, entertainment features, souvenirs and light refreshments after the evening session.

The Committee in charge of the arrangements consisted of Messrs. J. Gorso, Columbia University, H. Lowenstein, New York University, N. N. Wolpert, W. Sumner and M. Bernner, Brooklyn Polytechnic Institute, and L. V. Aquadro and H. E. Beaven, Stevens Institute of Technology.

Section Meetings

ATLANTA

April 9. Mr. W. G. Eager, Assoc.Mem.A.S.M.E., gave an interesting address on The Effect Upon Fuel Economy of Different Arrangements of Baffles in Boiler Tubes.

CECIL P. POOLE,
Section Secretary.

BALTIMORE

The Section has been recognized by the Fuel Administration and one of its committees, composed of Messrs. Henry Adams, A. E. Walden, W. W. Varney, and A. G. Christie, has been coöperating with the Fuel Administration and the Liberty Loan Committee, in regard to the third Liberty Loan. At the present time the A.S.M.E. Section in coöperation with the Engineers' Club is taking prominent part in engineering matters of public interest in Baltimore.

A. G. CHRISTIE,
Section Secretary.

BIRMINGHAM

February 22. At a joint meeting of the Alabama Technical Association with the A.S.M.E. Section, C. B. Davis, Mem.Am.Soc.M.E., presented a paper on the subject of Fuel Conservation and Increased Production. A résumé of the paper showed:

1 That the possible conservation of coal will be a saving of approximately 126,370 tons annually if the necessary methods are adopted at the various plants as suggested;

2 That the possible saving by making all coke in by-product ovens will be approximately 689,750 tons of coal annually;

3 That an output of approximately 2,000,000 tons annually can be obtained at a cost of approximately $2,000,000 for the initial investment and requiring in the way of new labor 3500 men;

4 That the present output will be increased by 5,340,000 tons at an initial cost of $3,840,000 and showing an annual saving of $1,770,000; and

5 That a further increased production could be made by more efficient transportation and utilization of the Warrior and Alabama Rivers for transportation.

Mr. F. G. Cutler, Mem.Am.Soc.M.E., called attention to conditions in Alabama for the saving of fuel and showed that the tendency is to use water power and surplus gas from blast furnaces and by-product ovens. The use of low-pressure-turbine-driven generators in the Birmingham district alone would affect a saving in excess of that quoted by Mr. Davis. He ventured the prediction that within a few years the consumption of coal under boilers for the production of power would be practically eliminated.

Mr. H. M. Gassman, Mem.Am.Soc.M.E., pointed out the difficulty of opening up new mines and modernizing existing mines on account of the large amount of capital invested; and also the difficulty of obtaining equipment and securing labor necessary to operate them. He suggested that a conservation campaign be waged and industrial plants consuming more than five tons per day be urged to conserve coal.

Mr. H. S. Geismer claimed that the opening of new mines would not be feasible at the present time, due to the shortage of labor in the district, which is not sufficient to work the present mines to their full output per man employed. He pointed out that electrification would not be an immediate remedy, due to the difficulty of obtaining deliveries of mining machinery and other equipment. Also that the mines best adapted for that type of equipment have already been electrified. He sugested a campaign to make the miners themselves realize that they alone could increase the output and said that almost without exception the miners are not working full time nor do they seem to realize their duty to the Government in the present crisis.

Mr. M. J. Lide, Mem.Am.Soc.M.E., pointed out the losses due to inefficient steam engines, where more waste could be accounted for than at the boilers. Special stress was laid on the question of instructing labor.

The subject was also discussed in its various phases by Samuel Stewart, R. A. Lee, W. F. Wilcox, G. N. Mitcham, J. T. McKenzie and B. B. Ross.

The following resolution was adopted unanimously:

> RESOLVED, That it is the sense of the Alabama Technical Association to urge operators to run their plants with the greatest possible regard for the conservation of fuel and also that employees and operators coöperate to run mines and industrial plants continuously and at the best possible output, making such sacrifices as are necessary with a view of furnishing a maximum production, and thereby very materially assisting our Government in bringing the war to a prompt and successful conclusion.

April 25. Mr. J. W. Moore, Assoc.Mem.Am.Soc.M.E., delivered an interesting paper on The Gas Producing Plant of the American Cast Iron Pipe Company.

W. L. ROUECHE,
Section Secretary.

BOSTON

April 30. At a joint dinner of the Engineering Societies of Boston Mr. Alfred D. Flinn, Secretary of the Engineering Council, delivered an address on the work of the Engineering Council. Further details regarding the meeting will be published in a succeeding issue of THE JOURNAL.

W. G. STARKWEATHER,
Section Secretary.

BUFFALO

March 27. Prof. D. S. Kimball, Mem.Am.Soc.M.E., delivered a lecture on Water Powers of the Pacific Coast, which was not only of unusual technical interest, but was illustrated with many lan-

tern slides of great beauty, since practically all of the power plants described were situated at places of unusual scenic grandeur.

April 3. At a special meeting of the Buffalo Engineering Society, Mr. N. Boland, of the Beyers Manufacturing Company, delivered an illustrated lecture on The Manufacture of Wrought Iron Pipe, showing the manufacture of wrought iron pipe from pig iron to the finished product.

April 10. At the seventh general meeting of the Buffalo Engineering Society, Eskil Berg, of the General Electric Company at Schenectady, gave a talk on The Recent Development of Propelling Machinery for War and Merchant Ships. The speaker brought out the recent advances in the use of the steam turbine with electric drive for propulsion of war and merchant vessels, showing that high efficiency, at various speeds can be obtained with the electric drive, and pointing out its advantages over the gear drive for large power installations. The water rate per b.hp. of turbine installations with electric and gear drive was compared with that for the same type of ship equipped with reciprocating engines and it was shown that the large turbine installations are more economical than the best types of reciprocating engine installations, particularly when two or three speeds must be maintained for long periods as mentioned above. Mr. Berg's close connection with the war vessels now being built made it possible for him to bring out the latest and the expected future developments of the turbine equipment upon which much work and study has been put.

April 17. Under the auspices of the Electro-Chemical Section, Mr. Oliver C. Ralston, Metallurgist for the Hooker Electro-Chemical Company, Niagara Falls, gave a talk on Recent Advances in Western Non-Ferrous Metallurgy.

E. B. NEIL,
Section Secretary.

CHICAGO

April 22. At a joint meeting of the Chicago Sections of the A.S.M.E., A.I.E.E. and the Mechanical and Electrical Sections of the Western Society of Pennsylvania, C. F. Kettering, Mem. Am.Soc.M.E., delivered an interesting paper on The Automobile Power Plant.

A. L. RICE,
Section Secretary.

CINCINNATI

March 21. A joint meeting of the Engineers' Club of Cincinnati and the A.S.M.E. Section which included two sessions, was held at the Literary Club rooms. The afternoon session was opened by Henry Ritter, Mem.Am.Soc.M.E., with a paper on Shop Kinks, in which he dealt with the subject of shop management in general.

Prof. John T. Faig, Mem.Am.Soc.M.E., delivered a paper on The Economic Use of Coal by Communities which was illustrated by lantern slides. The waste inherent in the present methods of utilizing coal in cities of the Middle West was pointed out. A by-product coke-oven plant handling 7000 tons of coal per day and producing coke, gas, tar, ammonia and benzol was discussed from a business and economic standpoint and the economic advantage of the process and the addition to the raw materials of the country were shown.

Mr. C. U. Carpenter, Mem.Am.Soc.M.E., opened the evening session with a lecture on The Training of Women for Industry. He told of the training of thousands of women of no experience in mechanical lines for the manufacture of time fuses for Russian shrapnel. These women were recruited from all walks of life, and were absolutely ignorant of production work on machines, but by organizing a school apart from the shops, and selecting instructors very carefully, it was found possible to train the women so that they were not only capable of making the parts of these time fuses within the necessary degree of accuracy, usually within one thousandth of an inch, but it was also found possible to train them to give production superior to that secured from men. One of the interesting features of this experiment in the use of women on machine work was the fact that it was found possible to produce time fuses in enormous quantities that met every requirement of rigid inspection without any particular difficulty. In the course of the discussion which followed, Mr. Carpenter brought out the point that his method of organization and teaching was as directly applicable to men as to women, and in his opinion operatives should always be taught in a school separate from the shop. He believed this to be productive of much better results. Operatives whose skill does not appear to increase are withdrawn from the works and put in the school again, under careful instructors who study their defects and attempt to correct them.

The meeting proved to be a great success and there were over 150 persons in attendance.

JOHN T. FAIG,
Section Secretary.

CONNECTICUT SECTION

Bridgeport Branch

April 24.—The afternoon session was a general get-together meeting in order that those attending the dinner and evening session might be better acquainted. After the dinner, which took place in the Stratfield Hotel, the evening session opened with a patriotic address by Judge Pullman, of Bridgeport. The following gentlemen also addressed the meeting: Clinton E. Woods, of the Woods-Keller Company, on Factory Accounting as a Bill for Controlling Production; Harry E. Harris, Chairman of the Joint Gage Committee, A.S.M.E. and S.A.E., on Facilitation of War Production by Practicable Manufacturing Allowances; and Wm. R. Webster, Mem.Am.Soc.M.E., on Intelligent Specifications and Inspection as a Factor in Production Increase.

R. W. ELLINGHAM,
Branch Treasurer.

Meriden Branch

The Meriden Branch of the Connecticut Section met April 19th at the Chamber of Commerce Hall. Mr. F. C. Bolton, Tool Engineer at the Meriden Plant of the Colt Patent Fire Arms Manufacturing Co., gave a very interesting description and demonstration of the Browning Machine Rifle. The rifle upon which America is placing great dependence in the great struggle against autocracy, weighs 15 lb. and contains 110 parts. Its bullets travel through the barrel at a rate of 2700 ft. per second and it can fire twenty shots in from two to two-and-a-half seconds. In test, 20,000 shots were fired at high speed without a miss-fire. A feature of the gun is the magazine which holds 20 cartridges and which the operator drops to the ground by releasing a spring. Eight hundred rounds of ammunition can be carried by one man. Another feature of the gun is the ability to fire a single shot or a number of shots according to the will of the operator. Admission was restricted to invited guests, the attendance being slightly over 180.

C. N. FLAGG, JR.,
Branch Secretary.

New Haven Branch

April 16. Mr. George A. Orrok, Mem.Am.Soc.M.E., delivered an interesting paper on Internal-Combustion Engines. He described the development of the aeroplane engine and told of some very interesting recent experiences in connection with the new Liberty motor. This motor is entirely different from the one designed last summer. Comparisons of a number of makes of aeroplanes were made and the speaker stated that in his opinion it is not desirable to manufacture motors under 2.7 lbs. per h.p. Motors which have been developed in the last few months have been strengthened so that they have a working capacity of from 140 to 200 hours. Mr. Orrok said the Germans are now making motors for aeroplanes using the Diesel engine type.

The internal combustion engines made for other purposes were described and it was pointed out that the farmer of the present day depends exclusively upon these to do all of his chores, from tilling the soil to milking the cows, lighting his home, and delivering his produce to the markets.

Among those who joined in the discussion were Messrs. F. R. Low, Editor of Power, Professor L. P. Breckenridge, Professor E. H. Lockwood, S. F. Jeter, Secretary of the Hartford Branch, C. K. Decherd, Chairman of the Meriden Branch. Mr. H. B. Sargent presided.

Mr. Orrok addressed the Student Branch at Yale University in the morning on the same subject.

E. H. LOCKWOOD,
Branch Secretary.

ONTARIO

March 25. At the second annual meeting of the Joint Committee of Technical Organizations, to which the members of all of the engineering societies were invited, special emphasis was made by Col. David Carnegie to the need of training the directors and distributors of production, in order that the whole resources of the country might be devoted to the maximum state of efficiency toward winning the war. He made a strong appeal for greater industrial education in Canada. Preparation of the child for industrial training, he declared, was the immediate need of the day, and urged upon his hearers the importance of strong action, either in the form of direct representations to the Government, or separate action by the organization, or by individuals. He also proposed the establishment of national and district trade boards.

Mr. W. E. Segsworth, Administrator of the Vocational Branch, Military Hospitals Commission, gave a most comprehensive and interesting explanation of the gigantic work undertaken in connection with the Invalided Soldiers' Commission.

Soldiers placed in factories by the commission are situated only after each individual case is thoroughly investigated as to the man's adaptability, and these men are continually looked after by officers, usually engineers having wide experience in all branches of industry, to keep this labor from being exploited.

In closing, Mr. Segsworth impressed upon his audience the need of improved measures for the training and care of blind soldiers.

CHESTER B. HAMILTON, JR.,
Section Secretary.

PHILADELPHIA

March 27. At a joint meeting of the Engineers' Club of Philadelphia and the A.S.M.E. Section, Dr. S. W. Stratton, Director of the U. S. Bureau of Standards, presented a paper on The Relation of the Bureau of Standards to the War, in which he dealt with the scientific work of the Government. Following the lecture a patriotic address was made by Corp. Frank Street, of the British Strathcona Horse.

April 23. After a visit to the A.I.S.C. at Hog Island and the Wm. Cramp Ship and Engine Building Company's yards, the Council of the Society attended a dinner meeting of the Section held at the Adelphia Hotel. The subject of the meeting was Shipbuilding and was discussed from all points of view. A more detailed account of the meeting will appear in a succeeding issue of THE JOURNAL.

JOHN P. MUDD,
Section Secretary.

PROVIDENCE

March 27. Under the auspices of the Municipal Engineering Section, Frederick N. Connet, Mem.Am.Soc.M.E., delivered an illustrated lecture on Recent Developments in the Use of the Venturi Meter.

March 28. A social meeting of the Efficiency Section was held at which W. H. Harriman, of the Universal Winding Company, related his personal experiences in engineering in Mexico.

March 29. At a joint meeting of the Chemical Section of the Providence Engineering Society and the Rhode Island Section of the American Chemical Society, Frederick H. Franklin, connected with Saunders & Franklin, delivered an illustrated lecture on The Metallography of Cast Iron.

April 9. Following a business meeting W. A. Kennedy, Mem. Am.Soc.M.E., presented a paper on Bronze and Its Uses.

April 10. The subject of the meeting held under the auspices of the Power Section was Mill Heating and Lighting.

JAMES A. HALL,
Correspondent.

ST. LOUIS

March 29. After the regular monthly dinner Dr. Isaac Lippincott, associate professor of economics at Washington University, delivered one of the most interesting addresses ever presented before the Section, on Economic Reconstruction After the War.

R. L. RADCLIFFE,
Section Secretary.

SAN FRANCISCO

March 20. An informal dinner was tendered Prof. George F. Swain, Mem.Am.Soc.M.E., and Past-President of the Am.Soc.C.E., by the joint Sections of the A.S.C.E., A.I.M.E., A.I.E.E. American Chemical Society, and the A.S.M.E. Among the many speakers of the evening were the following: P. M. Downing, chief engineer of the Pacific Gas & Electric Company, who delivered a talk on Interconnection of Power Plants; Prof. D. M. Folson, who presented the subject of Fuel Oil Saving; Mr. Max Thelen, President of the State Railroad Commission, who spoke on the subject of War Activities of the Railroad Commission, and Professor Swain, who selected the vitally important subject of National Issues of Today. The meeting was presided over by Prof. C. D. Marx, of Leland Stanford, Jr. University.

C. H. DELANY,
Section Secretary.

Student Branch Meetings

NEW YORK STUDENT BRANCHES

As has been customary for the past few years the Metropolitan Student Branches at Columbia University, New York University, Polytechnic Institute of Brooklyn and Stevens Institute of Technology, again held their Joint Meeting. This year, however, the meeting was held jointly with the New York Section on April 9th, and included an afternoon session, a buffet supper and an evening session. The meeting was a great success and the attendance as large as the well attended sessions of the Annual meetings. The Student Committee in charge of the arrangements are to be congratulated upon their enterprise. The Committee included: Messrs. J. Gorso, Columbia University, H. Lowenstein, New York University, N. N. Wolpert, W. Summer and M. Bernner, Polytechnic Institute of Brooklyn, and L. V. Aquadro and H. E. Beaven, Stevens Institute of Technology.

The convention, for such it was in fact, established a new record, which, in these times of depleted student ranks owing to student service in the war, reflected great credit on the enterprise and ability of the committee having the meeting in charge. The entire affair was held on the fifth floor of the Engineering Societies' Building, the capacity of which was taxed to the utmost. Four hundred students and local members attended the "pay-as-you enter" buffet dinner and nearly 700 were present at the evening session.

At the afternoon session talks were given by several engineers as follows:

WANTED: CAPTAINS OF INDUSTRY AFTER THE WAR. M. H. Avram, President Slocum Avram Slocum Company.

WHAT THE ENGINEER HAS DONE FOR THE WAR. F. R. Low, Editor of *Power*.

ENGINEERING PROBLEMS OF THE WAR. Geo A. Orrok, Consulting Engineer.

CERTAIN PHASES OF ENGINEERING EDUCATION. Prof. Collins P. Bliss, New York University.

ORGANIZATION AND THE RELATION IT BEARS TO ENGINEERS. Charles Whiting Baker, Consulting Engineer and Consulting Editor of *Engineering News-Record*.

At this session an interesting announcement was made by Prof. Bliss of a new educational plan proposed by New York University for greater co-operation between the University and the industries. The plan contemplates 20 scholarships of $25,000 each, in return for which special opportunities in research work and in the use of the facilities of the University will be available. Classes are to be divided into two sections which will alternate every other term between the University and the co-operating industry.

In the interval following the dinner the audience was highly entertained by "Jack" Armour of *Power*, and during the evening selections were given by the orchestra from Polytechnic Institute of Brooklyn. The evening programme comprised the following addresses:

THE YOUNG ENGINEERS IN THE PRESENT CRISIS. Past-President Ira N. Hollis.

CERTAIN ACCOMPLISHMENTS OF THE NAVY IN THE WAR. Lieut. B. F. Hart of the Brooklyn Navy Yard.

THE WAR IN THE AIR. G. Douglas Wardrop, Editor *Aerial Age*; illustrated by lantern slides and moving pictures.

UNIVERSITY OF CALIFORNIA

February 28. Mr. Domonoske, instructor of machine design at the University, gave an interesting account of student life and work at the University of Illinois.

March 14. At this meeting two papers were presented, one on The Gnome Engine, by E. K. Schulze, and the other on The Spillway of Calavaras Dam, by Prof. J. N. Le Conte.

March 28. Mr. H. L. Reich presented a paper on Power Plants of the San Joaquin Light & Power Co., and Prof. B. F. Raber gave an interesting talk on Dynomometers.

LLEWELLYN BOELTER.
Branch Secretary.

CARNEGIE INSTITUTE OF TECHNOLOGY

April 10. Mr. W. G. Chester, of the Babcock & Wilcox Company, gave an illustrated talk on the various types of boilers manufactured by this company, dealing mainly with the features of the land and marine types. The inability of makers to standardize their product, he said, was a result of the demand for many different types, each especially adapted to peculiar conditions of operation. The difference in design between the ordinary and the marine boiler due to the requirements for compactness and high capacity was clearly shown by many excellent slides.

H. D. KRUMMEL.
Branch Secretary.

UNIVERSITY OF CINCINNATI

March 1. Mr. Fosdick, civil engineer for the W. G. Franz Co., gave a talk on the Dixie Terminal Building to be erected in Cincinnati, which is to serve as an office building for the Kentucky Green Line and the new rapid transit cars. Problems which a contractor has to overcome to fill his contract involving the solving of labor troubles, the advantages and disadvantages of concealing steam piping, considerations in laying out heating systems, problems of sanitation, deciding upon materials of construction, laying out decorating and lighting effects, placing exits properly so as to avoid standing lines during rush hours, and the question of getting supplies such as building materials, were all accurately traced.

March 21. Mr. Hinkle, who has been speaking at the various army cantonments throughout the country, delivered an intensely interesting talk on The Evolution of the U. S. Army Rifle, and exhibited a collection of twenty guns showing those used by our army and navy from the Revolutionary War to the present time. The working principles of the most important types of small arms, the methods of loading the gun and the various forms of ammunition used were discussed in detail.

C. L. KOEHLER.
Branch Secretary.

KANSAS STATE AGRICULTURAL COLLEGE

March 7. Mr. J. B. Marcellus, of the Portland Cement Manufacturing Association, who is at present carrying on research work at the college, gave a talk on Cement, in which he traced the methods of manufacturing cement from the early days.

March 28. Mr. Walter Miller, of the Shop Practice Department, gave a talk on Military Training in Switzerland, tracing the various steps and processes as developed by the Swiss Government in training their fighting forces.

I. O. MALL.
Branch Secretary.

UNIVERSITY OF KANSAS

April 4. A plan of reporting on articles published in technical magazines was tried out and the articles appearing in a recent issue of *Power* on the Tamarack Power Plant and on Training Engine Room Crews for American Crews were fully discussed.

H. C. VAN HOUTEN.
Branch Secretary.

LEHIGH UNIVERSITY

April 3. A lecture on Modified Springfield Ammunition as made by the Union Metallic Cartridge Co., was delivered by Mr. B. P. Lauder. Specimens tracing the shell from the brass disk to the completely drawn shell were shown and the speaker also told how bullets are cast and jacketed.

Mr. L. J. Jenkins gave a lecture on the Brief History of the Development of the Steam Engine, tracing its progress from the time of its invention by Watt to the present date.

Mr. E. L. Forstall delivered a paper on the Work of the American Army Engineers in France, showing how the corps has been enlarged and how it has been working in France to provide efficient transportation for the American Army.

N. DMYTROW, JR.,
Branch Secretary.

LOUISIANA STATE UNIVERSITY

February 14. The following officers were elected for the ensuing year: E. C. Freeland, chairman; J. Lobo, vice-chairman; C. R. Strattman, secretary; O. A. Wing, treasurer.

A brief address was given by E. C. Freeland, explaining the advantages of joining the A.S.M.E. upon graduation.

March 20. Following the business meeting a very interesting and instructive talk was given by Mr. Piller, Chief Electrician of the Standard Oil Co., on The Operation of Large Gas Engines as used by the Standard Oil Company of Louisiana.

C. R. STRATTMAN.
Branch Secretary.

UNIVERSITY OF MAINE

February 13. Two papers were presented, one by Mr. Chapin on Static and Dynamic Balancing and the other on Motion Study as Applied to War Cripples, by Mr. Russell.

A. MASON RUSSELL.
Branch Secretary.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

April 5. Prof. Charles M. Allen, of the hydraulic engineering department, delivered an illustrated lecture on the Use of Dynamometers and Water Brakes in Tests on Power Plants.

By exhibiting rating curves of circular, Government and other rating stations, which coincided almost identically, he pointed out that in rating current meters a circular station is exactly as accurate as any other. Then by means of capacity-power and gate-opening power curves, it was shown that enough water was wasted in using full gate opening in preference to 0.85 of full-gate to run a separate unit, and that a loss of many dollars resulted.

S. H. CALDWELL.
Branch Secretary.

MICHIGAN AGRICULTURAL COLLEGE

March 7. Mr. Livingston, of the Reo Motor Car Company, presented a paper on Accident Prevention, pointing out the need of definite methods of preventing accidents. Progress has been made in this regard by the installations of mechanical safeguards, the inspection of plants periodically, by placing definite responsibility upon certain employes, and by the organized effort among foremen.

H. M. SASS,
Branch Secretary.

UNIVERSITY OF MISSOURI

March 8. Prof. H. Wade Hibbard, recently engaged in Washington making plans for organizing and making efficient certain departments relative to the war, gave a lecture on Organization Engineering. The underlying principles of efficiency management together with charts used in that work were explained in detail, such as charts representing the organization of an American railway, principle, production, procedure, and production-delays charts.

March 26. Mr. K. K. King presented a paper on The Design of Motor-Truck Engines for Long Life, discussing the factors which go to make up longevity. Methods used in designing rods, wrist-pin bushings, pistons, cylinders, camshafts, valves and other sundry parts were thoroughly described and the methods of

lubrication-splash feed, pressure feed, and splash-pressure feed traced as to their relative merits.

J. W. BALDWIN,
Branch Secretary.

OREGON AGRICULTURAL COLLEGE

March 27. Mr. M. L. Granning, instructor in machine-shop practice, gave a lecture on the Construction of a Modern Shrapnel Shell. Incidentally he pointed out the changes which have been made in several large industrial shops which now devote all or a majority of their time to the production of munitions.

NEAL K. FORD,
Branch Secretary.

STEVENS INSTITUTE OF TECHNOLOGY

March 4. Arrangements were reported regarding inspection trips. Election of officers for next semester took place on account of the senior class graduating in April, two months prior to regular graduation. This has been possible because of the war schedule which has been in effect since September. The following officers were elected: George H. Spencer, chairman; Harry E. Beaver, vice-chairman; Lincoln V. Aquadro, secretary-treasurer.

L. V. AQUADRO,
Branch Secretary-Treasurer.

UNIVERSITY OF WISCONSIN

MARCH 14. Professor Callan gave an account of his recent trip to Europe as a member of a committee sent by the United States Shipping Board. His talk covered briefly his trip over, a new gas engine using exhaust gas to generate steam which is used behind the piston, ship industries of England, gun and submarine building, aeroplanes and air raids.

WM. MANTONYA,
Branch Secretary.

WORCESTER POLYTECHNIC INSTITUTE

Died in France, February 15, 1918, E. W. Jones, United States Aviation Service, Student Member of Worcester Polytechnic Institute Branch.

March 8. At a meeting to which the members of the Civil Engineering Society were invited the subject of The Determination of Water Waste in American Cities by Pitometer Methods was presented by Edward S. Cole, Mem.Am.Soc.M.E. Mr. Cole used charts of pumpage against time to demonstrate how large an amount of water had to be furnished a city's mains, even during the night and on Sundays, and by subtracting from this the amount probably used during these periods, a surprisingly large quantity was still left which could only be accounted for as wastage. He then described two types of apparatus for measuring the flow in city mains, one being the Deacon meter and the other the pitometer, with photographic recording attachments. Several experiences in tracing out wastage in metropolitan districts were related. The method of isolating a district by shutting off communicating mains was shown, together with the telltale drops in the pitometer record.

H. P. FAIRFIELD,
Branch Secretary.

YALE UNIVERSITY

March 15. J. Douglas Wardrop, member of the A.I.E.E. and editor of the *Aerial Age*, delivered a most instructive illustrated lecture on The War in the Air, tracing the history and development of the various types of aeroplanes and aircraft in general and pointing out the speeds, cruising radius, carrying capacity and horsepower of the various English, American, French, Italian and German planes.

The importance now and in the future of aeroplanes adapted to both war and peace service, showing their suitability to submarine detection and aerial photography, was also touched upon.

WM. ROGERS HEROD,
Branch Secretary.

ROLL OF HONOR

ASHLEY, EDWARD E., JR., Captain, Signal Corps, U. S. Army.
BARLOW, FREDERIC C., Captain, Engineers, 10th Regiment Forestry, U. S. R., American Expeditionary Force, France.
BERG, H. J., Lieutenant, Aviation Section, Signal Officers' Reserve Corps, Ellington Field, Olcott, Texas.
BROCK, CLARENCE A., Field Hospital No. 34, Camp Greenleaf, Medical Officers' Training Camp, Fort Oglethorpe, Ga.
BURRAGE, CHARLES W., U. S. Naval Air Service.
CARPENTER, CHARLES I., Approvals Section, Finance Department, Equipment Division, Signal Corps, U. S. Army.
CARTER, CLIFFORD R., Equipment Division, Aviation Section, Signal Corps.
CHRISTEN, A. B., First Lieutenant, Signal Corps, American Expeditionary Force, France.
CLENDON, G. W., Officers' Training School, Artillery Section, Camp McClellan, Ala.
COOKE, EUGENE L., Coast Artillery Corps, U. S. Army, Fort Monroe, Va.
DENT, JOHN A., Captain, Ordnance Department, National Army, American Expeditionary Force, France.
DUFFY, FRANK J., Lieutenant-Colonel, 103rd Regiment Engineers, Camp Hancock, Augusta, Ga.
ERICSON, EDWARD O., First Lieutenant, Ordnance Officers' Reserve Corps.
FLOWERS, ALAN E., Captain, U. S. R., Signal Corps, Land Division, Radio Development.
FULLER, FLOID M., Lieutenant, U. S. Naval Reserve Force, Assistant Naval Inspector of Ordnance.
GILMORE, JOHN W., Captain, Coast Artillery Corps, U. S. Army.
GREMMEL, HENRY F., Second Lieutenant, Ordnance Officers' Reserve Corps.
HARTZELL, EARL F., Co. A, 319th Engineers, Camp Fremont, Cal.
HEILMANN, CARL A., 303rd Engineers, American Expeditionary Force, France.
HOSKINS, STEPHEN P., Candidate, Third Officers' Training Camp, Camp Lee, Va.
HUBBARD, GUY, Ordnance Department, N. A., Ordnance Training School, Dartmouth College, Hanover, N. H.
HUNTER, CHARLES F., Major, Ordnance Department, N. A., Frankford Arsenal, Philadelphia.
JOHNSTON, A. LANGSTAFF, JR., Lieutenant, Inspector of Machinery, U. S. Navy.
KEET, CLARENCE T., Second Lieutenant, Engineers, N. A., 5th Co., Engineer Reserve Officers' Training Camp, Camp Lee, Va.
KULLING, O. W., Headquarters Co., 315th Infantry, Camp Meade, Md.
LA FON, ALPHONSE, First Lieutenant, U. S. R., 18th Co., Coast Artillery Corps, Fort Hancock, Sandy Hook, N. J.
LINDBLOM, HERBERT R., Corporal, Co. E., 301st Engineers, Camp Devens, Mass.
LOGAN, LLOYD, Private, Co. D, 1st Quebec Regiment, Canadian Expeditionary Force.
LOHMANN, ALFRED P., Lieutenant-Commander, Naval Reserve Flying Corps.
MCJILTON, JOHN P., First Lieutenant, 65th Engineers, Camp Meade, Md.
MABBOTT, H. C., First Lieutenant, Coast Artillery Corps, Fort Totten, New York.
MAURY, DABNEY H., Lieutenant-Colonel, Construction Division, Quartermaster Corps, N. A.
MILLER, FRED J., Major, Ordnance Officers' Reserve Corps, Rock Island Arsenal, Rock Island, Ill.
MONTGOMERY, H. M., Major, Quartermaster Corps, N. A.
MORRILL, GUY L., Sergeant, Quartermaster Department, U. S. Army.
MORSE, E. R., First Lieutenant, Ordnance Officers' Reserve Corps, 6th Ammunition Train, 6th Division, Headquarters, Camp McClellan, Ala.
NEWMAN, W. C., Warrant Gunner, U. S. Naval Reserve Force, Boston Navy Yard, Charleston, Mass.
PARKS, BURRITT A, Captain, Engineer Officers' Reserve Corps.
RECKFORD, JOHN KING, Lieutenant, Junior Grade, Naval Reserve Flying Corps.
ROBERTSON, ELROY C., Equipment Division, Signal Corps, U. S. Army.
ROSENFIELD, HAROLD, Aviation Section, Signal Corps, Reserve Officers' Training Camp.
ROYAL, JAMES M., Second Lieutenant, Aviation Section, Signal Officers' Reserve Corps, School of Military Aeronautics, M. I. T.
RUTH, R. W., Chief Storekeeper, U. S. Naval Reserve Force, assigned to Washington, D. C.
SAURWEIN, GEORGE K., Captain, Ordnance Officers' Reserve Corps.
SCHALLER, ALWIN L., Captain, Ordnance Department, N. A., Aberdeen Proving Ground, Aberdeen, Md.
SUMMERS, DANIEL, Captain, 28th Engineers (Quarry), N. A., Camp Meade, Md.
TAYLOR, JOHN E., 31st Engineers (Railway Operation Regiment), U. S. Army.
WADSWORTH, J. FREDERIC, Co. A, Machine Gun Battery, No. 313, Camp Lee, Va.
WALBRIDGE, ARTHUR H., Ensign, U. S. S. *Arkansas.*
WIDDICOMBE, R. A., Major, Quartermaster Corps, U. S. Army.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary, and items should be received by May 16 in order to appear in the June issue.

CHANGES OF POSITION

CHARLES F. MERRILL, formerly assistant chief draftsman of the Draper Corporation, Hopedale, Mass., has entered the engineering department of the James Hunter Machine Company, of North Adams, Mass.

DWIGHT K. BARTLETT, until recently assistant treasurer of the Builders Iron Foundry, Providence, R. I. has become associated with the Electro Bleaching Gas Company, and the Niagara Alkali Company, with headquarters at New York City.

HARRY K. FOX has assumed the duties of engineer of tests of the Chicago, Milwaukee and St. Paul Railway, Milwaukee, Wis. He was formerly connected with the Western Maryland Railway Company, Hagerstown, Md., in the capacity of chief draftsman of the motive-power department.

ERFORD J. PEEBLES has resigned his position of production engineer for the New Haven Clock Company, New Haven, Conn., to take a position on the staff of C. E. Knoeppel and Company, New York. He has been assigned to industrial engineering duties for the Emergency Fleet Corporation, U. S. Shipping Board, Washington, D. C.

ELROY C. ROBERTSON, formerly with the Frantz Premier Company, Cleveland, Ohio, is now associated with the New York District Equipment Office, Signal Corps, U. S. A.

D. B. CLARK, formerly superintendent of the shell department of the American Brake Shoe and Foundry Company at Erie, Pa., is now general superintendent of the Watervliet Arsenal, Watervliet, N. Y. Mr. Clark has charge of the entire production of this plant which is the largest and oldest arsenal in the United States.

WILLIAM C. FISHER, formerly affiliated with the Griscom-Russell Company, New York, has become associated with the American Agricultural Chemical Company, Liebig Works, Carteret, N. J.

R. A. WENTWORTH, until recently superintendent of the Saco-Lowell Shops, Lowell, Mass., has assumed the duties of assistant superintendent of the U. S. Cartridge Company, of the same city.

R. H. DUNBAR, formerly mechanical engineer with the American Tube and Stamping Company, Bridgeport, Conn., has accepted a position with the Providence Engineering Corporation, of Providence, R. I.

JOHN E. LOVELY, formerly connected with the Vermont Farm Machine Company, Bellows Falls, Vt., has become associated with the Jones and Lamson Machine Company, Springfield, Vt.

V. J. MOHLER has assumed the position of factory manager with the Moore Motor Vehicle Company, with offices at Danville, Ill. He was formerly identified with the C. J. Tagliabue Manufacturing Company, of Brooklyn, N. Y., as assistant manager of factories.

HENRY S. ISHAM, until recently affiliated with the New York Railways Company, New York, as draftsman, has entered the employ of Ford, Bacon and Davis, of New York, in the capacity of assistant engineer.

STANLEY MUNSON has left the engineering department of the Proctor and Gamble Manufacturing Company, Kansas City, Kan., to become chief engineer for Kirkman and Son, Brooklyn, N. Y.

E. BURTON SMITH, formerly affiliated with the Westinghouse Lamp Company, Bloomfield, N. J., has entered the employ of the International Arms and Fuze Company, Inc., of Bloomfield, N. J.

ALFRED L. AICHER, recently with the Southwark Foundry and Machine Company, of Philadelphia, Pa., has accepted a position with the Cresson-Morris Company, of the same city, in the engineering department.

JULIUS G. HATMAN, formerly superintendent of the Chattanooga Gas and Coal Products Company, Alton Park, Tenn., has become affiliated with the Union Carbide Company, Niagara Falls, N. Y.

J. GORDON SPARKES, recently associated with Robert D. Johnston, Jr., patent attorney of Birmingham, Ala., has joined the staff of the Standard Scientific Company, New York.

ALFRED D. WHITE has assumed the duties of chief operating engineer of the Standard Oil Company, of Brooklyn, N. Y. He was recently affiliated with the Economy Engineering Company, as manager of the New York office.

EDWARD J. BLANCHARD, formerly assistant engineer with R. Martens and Company, Inc., New York, has become associated with Young, Corley and Dolan, Inc., of the same city.

FRANK L. GLYNN, until recently secretary of the Wisconsin State Board of Industrial Education, Madison, Wis., has become affiliated with the Curtiss Aeroplane and Motor Corporation, Buffalo, N. Y.

CHARLES FOSTER has been appointed, by the Board of Water and Light Commissioners, general superintendent of the Public Utilities under their control, and assumed his new duties on April 1. He was formerly manager of the St. Paul office of Charles L. Pillsbury Company.

ANNOUNCEMENTS

ROY W. GIFFORD, affiliated with the Massey-Harris Company, Ltd., Toronto, Ont., Canada, as superintendent of the munitions department, has assumed the position of superintendent of the Toronto Works of the same company.

E. EDMUND JACKSON, of the H. W. Johns-Manville Company, is resident engineer in charge of roofing construction at the new Federal Shipbuilding Company's plant at Kearny, N. J.

HARRY HIMELBLAU, mechanical engineer with the American Steam Conveyor Corporation, Chicago, Ill., has been transferred from the Chicago office to the New York office of the organization and is now employed in the capacity of sales engineer.

DWIGHT S. COLE has discontinued his office as a consulting mechanical engineer and patent attorney, in Grand Rapids, Mich., due to failing health and sight. His plans for the near future include outdoor work of such a nature as may be helpful toward regaining normal health. He will continue to reside in Grand Rapids, and keep somewhat in touch with his former lines of activity.

MAJOR H. M. MONTGOMERY, Quartermaster Corps, N. A. has been relieved from his present station and duties and will proceed to Jeffersonville and take his station at that place for duty as construction quartermaster for the quartermaster storehouse to be located at that place.

MALCOLM CURRY, general engineer of the American Thread Company, Holyoke, Mass., KENNETH B. MILLETT, assistant general engineer, formerly at Willimantic, and A. C. RICHARDSON, of Holyoke, are now located at the head office of the company in New York, to which has been transferred the office of the general

engineering department of the American Thread Company, which was formerly at the Merrick Mills at Holyoke.

WILBUR M. BOSWORTH has recently had patented steel center constructions, or underframes, which are being used by the Norfolk Southern Railroad Company in reinforcing old freight cars. Mr. Bosworth, who was formerly mechanical engineer with the Norfolk Southern Railroad Company, has become connected with the engineering department of the Under-Feed Stoker Company, Chicago, Ill.

FRANCIS A. VAUGHN, senior member of the firm of Vaughn & Meyer, consulting engineers of Milwaukee and Wausau, and Charles L. Pillsbury Company, consulting engineers of Minneapolis and St. Paul, has been engaged by the School of Engineering of Milwaukee as business manager and director of engineering and industrial relations.

JAMES BRAKES, JR., has assumed the position of electrical tester for the Commonwealth Edison Company, of Chicago, Ill.

HARRY A. GOALWIN has become associated with Dr. Frederick Lester Stanton, of New York, and the two will act as consulting orthodontists and medico-technical engineers. Besides his work of developing this new field of mechanical engineering, Mr. Goalwin will continue his medical course at the College of Physicians and Surgeons, Columbia University, New York.

ARTHUR L. ROBERTS has been transferred from the position of mechanical engineer of the Lehigh Valley Railroad Company at South Bethlehem, Pa., to that of master mechanic of the same company, at Coxton, Pa.

SIDNEY DIAMANT, formerly at the De Mant Tool and Machine Co. of New York, is continuing his tool and manufacturing business under the firm name of the Diamant Tool and Manufacturing Co., Newark, N. J.

LOUIS ILLMER has become associated with the American Whaley Engine Company, Boston, Mass., in the capacity of mechanical engineer.

WILLIAM E. HAMILTON has become connected with the Standard Parts Company, of Cleveland, Ohio.

HENRY D. JACKSON, formerly of Timothy W. Sprague and Henry D. Jackson, consulting engineers of Boston, Mass., has joined the organization of Monks and Johnson, engineers and architects, of Boston, Mass., as power engineers, in charge of their power plant and heating work.

Stevens Institute of Technology, Hoboken, N. J., recently conferred the honorary degree of doctor of engineering upon J. WALDO SMITH, who was chief engineer on the new Catskill Aqueduct recently turned over to New York City to increase the water supply.

SIDNEY G. WALKER has been appointed vice-president of the Manufacturers' Mutual Fire Insurance Company, Providence, R. I., with which firm he was formerly connected in the capacity of engineer.

NECROLOGY

EDWIN A. STEVENS

Col. Edwin A. Stevens, member of the famous old American family which in Revolutionary days practically founded what we now know as the city of Hoboken, died on March 8, 1918, in Washington, D. C., where he was serving as a field officer of the Emergency Fleet Corporation.

He was born in Philadelphia on March 14, 1858, and attended St. Paul's School, Concord, N. H., later entering Princeton University, from which he was graduated in 1879 with the degree of A.B. In 1905 he was given the degree of Doctor of Engineering by the Stevens Institute of Technology, founded in 1868 by his father, Edwin A. Stevens.

He served as Park Commissioner and as Tax Commissioner of New Jersey and also served on the commission which settled the long-standing boundary dispute between the states of New York and New Jersey. For some time he was also Commissioner of the New York and New Jersey Palisades Interstate Park. In 1880 he was made adjutant of the old Ninth Regiment of New Jersey, and later served on the staff of Governor Ludlow. His appointment as Colonel of the Second Regiment came still later, and he was commander of the regiment for six years. In 1911 he was appointed Commissioner of Public Roads by President Wilson when the latter was Governor of New Jersey. In 1914 he was reappointed by Governor James F. Fielder and served until 1917, when the laws were changed and the management of the road department was taken out of the hands of a commissioner and invested in a commission of eight members.

Colonel Stevens designed the *Bergen*, the first screw-propeller ferryboat. This vessel is still in commission and operates between Hoboken and New York. That invention marked a signal departure in the construction of such vessels and one which proved so satisfactory that all other ferry lines adopted the patent. He had many other inventions of a mechanical nature to his credit. He was president of the Hoboken Ferry Company until 1896 when it was taken over by other interests, later being acquired by the Lackawanna Railroad.

A little more than a year ago Colonel Stevens was appointed a member of the State Highway Commission by Governor Edge.

He was a member of the Society of Naval Architects and Marine Engineers and of the Institute of Naval Architects in Great Britain. He became a life member of our Society in 1889.

LUCIUS LAWRENCE MOSES

LUCIUS LAWRENCE MOSES

Lucius L. Moses was born on November 26, 1868, in Marcellus, N. Y. He was educated in St. John's Military School, Manlius, N. Y., and later took a special shop course in Cornell University.

From 1889 to 1893 he served his apprenticeship with the Phœnix Foundry & Machine Co., Syracuse, N. Y. He then entered the employ of the Paragon Plaster Co., as construction and operating superintendent, having complete charge of the engineering work and of the manufacturing. His next position was with the Clyde Gas & Electric Co., Clyde, N. Y., as treasurer and general manager. Mr. Moses held chief engineer's papers for ocean-going vessels, and from 1901 to 1909 he was in the service of the United States Government in that capacity. In 1909 he became associated with Henshaw, Bulkley & Co., San Francisco, Cal., as construction engineer, and later became consulting engineer in charge of the engineering work of the Hallidie Machinery Co., Seattle and Spokane, Wash. At the time of his death he was practising as a consulting engineer in Seattle.

Mr. Moses was a member of the Marine Engineers' Association, Seattle and San Francisco. He became a member of the Society in 1912. He died on October 15, 1917.

CANDIDATES FOR MEMBERSHIP

TO BE VOTED ON AFTER JUNE 10

BELOW is the list of candidates who have filed applications since the date of the last issue of THE JOURNAL. These are classified according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate or Associate-Member, those in the third class under Associate-Member or Junior, and those in the fourth under Junior grade only. Applications for change of grading are also posted. Total number of new applications, 90.

The Membership Committee, and in turn the Council, urge the members to scrutinize this list with care and advise the Secretary promptly of any objections to the candidates posted. All correspondence in this regard is strictly confidential. Unless objection is made to any of the candidates by June 10, and providing satisfactory replies have been received from the required number of references, they will be balloted upon by the Council. Those elected will be notified about June 15.

NOTE. The Council desires to impress upon applicants for membership that under the present national conditions the procedure of election of members may be slower than under normal conditions.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Alabama

ENES, JAMES T., Designer, Tennessee Coal, Iron & R. R. Co., Birmingham

SIRNIT, JOHN A., Designing & Electrical Engineer, Alabama Power Co., Birmingham

California

CHURCHMAN, WILLIAM H., Superintendent of Pumping Stations, East Bay Water Co., Oakland

COOLEY, DICK M., Sales Engineer, Howe Scale Co., San Francisco

Connecticut

LANEY, FRANK R., Representative in Field of M. M., International Silver Co., Meriden

POST, JOHN D., Assistant to Chief Engineer, The American Brass Co., Ansonia

SHUBERT, GEORGE E., Supervisor of Barrel Department, Remington Arms-U. M. C. Co., Bridgeport

WOLFE, JOHN A., Power Superintendent, American Brass Co., Ansonia

District of Columbia

BRANTLEY, PETER P., Mechanical Draftsman, Gun Division Trench Warfare, Washington

HENSZEY, JOSEPH W., Captain, Ordnance Reserve Corps, Inspection Division, Washington

MESSER, THOMAS H., Captain, Engineer R. C., U. S. A., Washington

Illinois

DOWNING, FLOYD E., Efficiency Engineer, Troy Laundry Machine Co., Chicago

NICHOLLS, ALFRED T., Designer, Armour & Co., Motive Power Department, Chicago

Kansas

SCHOOLEY, SYLVESTER S., Instructor in Electrical Engineering, University of Kansas, Lawrence

Maryland

HUSS, HENRY, Second Vice-President, New York & Hagerstown Metal Stamping Co., Hagerstown

TALIAFERRA, JOHN C., Member of Executive Committee of Directors, Continental Can Co., Baltimore

Massachusetts

HILDRETH, CHARLES E., President and General Manager of Whitcomb-Blaisdell Machine Tool Co., Worcester

JACKSON, P. ANDREW, Mechanical Engineer, American Writing Paper Co., Holyoke

KNOWLES, LUCIUS J., President, Crompton & Knowles Loom Works, Worcester

MELLOR, ALFRED S., Expert Tool Engineer, Cambridge

MURRAY, JAMES A., Commission Merchant, Fall River

TURNER, FRANK A., Chief Engineer, Becker Milling Machine Co., Hyde Park

Michigan

THOMPSON, WILLIAM G., Mechanical Engineer, The United States Graphite Co., Saginaw

Missouri

MUDD, HERBERT K., Assistant Engineer, Steam Engineering Department, Union Electric Light & Power Co., St. Louis

SHANE, LOUIS, Commander, U. S. N., Acting Inspector of Machinery, Busch-Sulzer Diesel Engine Co., St. Louis

New Jersey

CAMPBELL, E. GORDON, Superintendent of Construction, Public Service Electric Co., Engineering Department, Newark

HYDE, THOMAS E., Works Manager & Assistant Secretary, Huhn Mfg. Co., Arlington

New York

CHAMPION, CHARLES H., Engineer Manager, Electrical Division, H. Boker & Co., Inc., New York

FOSTER, CHARLES L., Engineer, Ossining Chemical Works, Ossining

JOHNSON, GEORGE A., Consulting Hydraulic Engineer and Sanitary Expert, New York

McNULTY, ALEXIS C., Designing Mechanical Engineer, Westinghouse, Church, Kerr & Co., New York

MALCOLM, GEORGE H., Assistant Construction Manager, Otis Elevator Co., New York

PARSONS, CHARLES H., Engineer, Construction Department, American Locomotive Co., Schenectady

RUSSELL, JAMES M., Engineering Assistant, New York Telephone Co., New York

WHITE, CHARLES F., Superintendent of Machinery, A. Kimball Co., New York

Ohio

AMOLE, E. B., Sales Engineer, Hooven, Owens, Rentschler Co., Cincinnati

CARREL, J. WALLACE, Vice-President and General Manager, The Lodge & Shipley Machine Tool Co., Cincinnati

THOMPSON, W. G. C., Inspector, Youngstown Sheet & Tube Co., Youngstown

Oklahoma

BURRELL, THOMAS L., Manager, Burrell Eng. & Con. Co., Oklahoma City

Pennsylvania

BELL, FRANK B., President, Edgewater Steel Co., Pittsburgh

COLBURN, C. P., Major, Ordnance R. C., Officer in Charge and Superintendent Fuse Shop F. A., Frankford Arsenal, Philadelphia

CUSHING, SAMUEL D., Managing Director, John B. Semple & Co., Sewickley

DAVIS, LUTHER A., Production Superintendent, Standard Screw Co., Corry

JONES, CARL G., Transformer Engineer and Designer, Westinghouse Electric & Mfg. Co., East Pittsburgh

KEBLER, ELIOT A., President, Fawcus Mach. Co.; Special Representative, The Matthew Addy Co., Pittsburgh

PENROSE, CHARLES, Engineer, Executive Staff, Day & Zimmermann, Inc., Philadelphia

Tennessee

FISCHER, FRED W., Chief Engineer, Master Mechanic, Standard Knitting Mills, Knoxville

Washington

BRETHERICK, CLARENCE O., Mechanical Engineer, J. F. Duthie Co., Seattle

COX, ALLEN H., President and Manager, A. H. Cox & Co., Inc., Seattle

Wisconsin

DEVLIN, EDWARD C., President, Universal Machinery Co., Milwaukee

TESCHAN, WALTER F., President and General Manager, Milwaukee Concrete Mixer Co., Milwaukee

Canada

JENCKES, JOHN M., General Manager, Engineering & Machine Works of Canada, Ltd., Sherbrooke, Ontario

China

GAITHER, ROBERT H., Manager Engineering Department and Acting Agent, American Trading Co., Shanghai

Cuba

ANDERSON, ROBERT A., General Sales Manager, American Steel Co. of Cuba, Havana

LOMBARD, J. OSWALD, Senior Partner, Lombard & Co., Havana

FOR CONSIDERATION AS ASSOCIATE OR ASSOCIATE-MEMBER

Massachusetts

GELINEAU, EMRIE E., Draftsman, The Lamson Company, Lowell

WASHBURN, Edwin F., 1st Lieutenant, O. R. C., Watertown Arsenal, Watertown

Michigan
FASOLDT, KARL N., Heating and Ventilating Designer, Ford Motor Co., Detroit

Pennsylvania
HANDLOSER, BERTRAM F., Chief Engineer, Dilworth, Porter & Co., Inc., Pittsburgh
WILLIAMS, DAVID G., Chief Engineer, Pennsylvania Trojan Power Co., Allentown

Wisconsin
CLARK, EDWARD S., Plant Manager and Engineer, De Pere Manufacturing Co., De Pere

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

District of Columbia
WILSON, ROGER J., Computer in the Seacoast and Railway Mount Section, Engineering Bureau, Ordnance Department, Washington

Kansas
BOWMAN, GEORGE M., Senior Student in Electrical Engineering at University of Kansas, Lawrence

Maryland
RIDER, ALBERT L., Contracting Engineer, Albert L. Rider, Baltimore

New York
COLLINS, WILLIAM, Assistant Engineer, Walter Kidde & Co., Inc., New York
FREAS, H. LEROY, Mechanical Engineer, New York District for Elliott Co. of Pittsburgh, Pa., New York
GRIFFIN, CECIL M., Testing and Erecting, Alberger Pump & Condenser Co., New York
JAMISON, GEORGE S., Engineer, Underwriters' Bureau of the Middle and Southern States, New York
ROBINSON, RALPH L., Engineer, Salesman, Griscom-Russell Co., New York
RYAN, JOHN A., Assistant Engineer, H. Boker & Co., Inc., New York

Ohio
ENGEL, PAUL H., Lieutenant, O. R. C., Dayton

Pennsylvania
DUKE, HENRY T., Equipment Specification Engineer, Ballinger & Perrot, Philadelphia

Porto Rico
CERECEDO, JAVIER H., General Manager, J. H. Cerecedo & Co., San Juan

FOR CONSIDERATION AS JUNIOR

District of Columbia
MALEY, ROBERT C., 2nd Lieutenant, Ordnance R. C., Washington
WALEN, ERNEST D., Associate Physicist, Bureau of Standards, Washington

Florida
FRANKS, NORVIN H., Material Agent, Ship Installing Yard for Emergency Fleet Corp., California Brick Co., Jacksonville

Illinois
BOLLING, JOHN E., Chief Engineer, Drying Systems, Inc., Chicago
CHOATE, DONALD H., 2nd Lieutenant, 332nd Field Artillery, Camp Grant

Maine
MARBLE, GERALD C., Proprietor, Skowhegan Monumental Works, Skowhegan

Michigan
MEISENZAHL, JULIUS A., Inspector A. and A.E., Detroit District Equipment Office, Engineering Department, Detroit

New Jersey
FEIST, SEYMOUR, Production Engineer, Standard Aircraft Corporation, Elizabeth
FORD, WENDELL B., Aeronautical Engineer, Aeromarine Plane & Motor Co., Keyport

New York
CONNOR, WILLIAM B., President, W. B. Connor, Inc., New York
EVERETT, RUSSELL W., Mechanical Engineering, Alberger Pump & Condenser Co., New York
IGLEHEART, GEORGE P., Ensign, U. S. Naval Reserve, Office of Superintending Constructor of Aircraft, Curtiss & Co., Buffalo
TYLER, HOWARD H., Testing Engineer, Alberger Pump & Condenser Co., Newburgh

Ohio
MADISON, HARRY A., Naval Aviator, U. S. Naval Reserve Flying Corps, Cambridge

Pennsylvania
RAMAGE, RAYMOND W., Assistant to Production Engineer, Bethlehem Steel Co., Reading

Virginia
DEGLER, HOWARD E., Instructor in Mechanical Drafting and Science, Hampton Institute, Hampton

Wisconsin
HUTCHENS, RALPH W., Mechanical Engineer, Gillette Rubber Co., Eau Claire

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Canada
SMALLWOOD, R. L., General Sales Manager, Dodge Manufacturing Co., Ltd., Toronto

PROMOTION FROM ASSOCIATE-MEMBER

Maryland
FELKER, GEORGE F., Major of Ordnance, National Army, Engineering Bureau, care Gunpowder Reservation, Baltimore

Tennessee
WILFERT, GEORGE, Captain Ordnance R.C., Army Inspector of Ordnance, Columbian Iron Works, Chattanooga

Canada
GIFFORD, ROY W., Superintendent Toronto Works, Massey-Harris Co., Ltd., Toronto

PROMOTION FROM JUNIOR

District of Columbia
BATES, HARRY H., 1st Lieutenant, Ordnance Department, U.S.A., Washington

Massachusetts
COOK, HARRY H., Chief Engineer, The Chapman Valve Mfg. Co., Indian Orchard
WILSON, CHESTER W., Assistant Shop Superintendent, Boston Navy Yard, Boston

New Jersey
STONE, EDWIN W., Assistant Production Manager, Whitehouse Le Compte Mfg. Co., Newark

New York
WHEELER, SETH, JR., Vice President & General Superintendent, A. P. W. Paper Co. (Reinstatement), New York

SUMMARY

New applications	90
Applications for change of grading	8
Promotion from Associate	1
Promotion from Associate-Member	3
Promotion from Junior	5
Total	107

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping any one desiring engineering services. The Society acts only as a clearing house in these matters.

GOVERNMENT POSITIONS

Stamps should be inclosed for transmittal of applications to advertisers; non-members should accompany applications with a letter of reference or introduction from a member; such reference letter will be filed with the Society records.

PROCESS INSPECTOR. Man should be capable of taking initiative in bettering conditions and methods of cartridge manufacture. Should be familiar with punch presses, drawing presses, and production on a large scale. Location, Massachusetts. 2596-A.

DIMENSIONAL INSPECTOR OF FINISHED COMPONENTS. Familiar with design and use of special gauges, verniers, etc. Location, Massachusetts. 2596-B.

BALLISTIC ENGINEERS to work on velocity and accuracy tests and data. Location, Massachusetts. 2596-C.

MAN conversant with shipping, tracing, and traffic management. Location, Massachusetts. 2596-D.

COMPETENT OFFICE MANAGER, capable of taking charge of, and disposing of, all office detail in plant. Location, Massachusetts. 2596-E.

All of the above preferably beyond draft age, or if of draft age, outside of Class 1.

NUMBER OF MEN needed for duties in connection with the maintenance and operation of utilities, such as electric lighting, water supply, road construction, steam-heating plants, building repairs, etc. These men to be above draft age, and in addition to their technical knowledge, should be men who are capable of team work. 2604.

MEN WITH PRACTICAL PRODUCTION EXPERIENCE wanted as assistant superintendents. Those in late classification of draft considered. Location, New York. 2605.

ENGINEERS able to read and translate French, with some experience in the manufacture of steel and steel forgings. Men

above draft age. Location, New York City 2606.

PLANT ENGINEER, man of wide experience for work of exceedingly varied character. 2607-A.

ASSISTANTS TO OFFICERS IN CHARGE OF SHOPS. Men over draft age familiar with machine shop practices. 2607-B.

LUBRICATION ENGINEERS, qualified both in the theory and practice of the internal-combustion engine, as well as in the handling of lubricants, and the engineering side of lubrication. 2608.

CIVILIAN POSITIONS

SUPERINTENDENTS, ASSISTANTS, FOREMEN AND CHIEF OPERATORS. Chemical, electrical, electrochemical, gas, liquid air, refrigerating and mechanical engineers, all with operating experience. Staff of one hundred big men wanted by large industrial plant in Alabama engaged in important Government work. College men with technical training and familiar with cement, power, refrigerating, chemical, sugar refining and electric plants; operators experienced on mining and milling machinery, crushers, conveyors, compressors, furnaces, kilns, ovens. Competent men will be trained in the processes, paid good salaries during instruction, and given an attractive contract as soon as qualified. State age, nationality and experience. 088-E.

MAN WITH TECHNICAL TRAINING as mechanical engineer wanted in inventory and appraisal department of one of the eastern state commissions; one year or more experience in engineering work preferred. Some knowledge of accounting and of appraisal work desirable but not essential. Present engineering staff is small and good opportunity for advancement. Location, New Jersey. 0168-E.

STEAM PLANT SUPERINTENDENT for large paper mill in Canada. Engine room experience not necessary but technical education desirable. Salary commensurate with ability. 0169-E.

SUPERINTENDENT for boiler and machine shop employing about 100 men, building water-tube marine boilers; some engine work. Technical man about 35 years old with broad acquaintance and ability to handle men, and actual experience in similar work. Exclusively Government contracts. Excellent opportunity for advancement. State age, nationality, salary, present employment, reference, and when available. Location, South. 0170-E.

ASSISTANT SUPERINTENDENT for outside erection work. Location, South. 0171-E.

CHECKER AND TWO MECHANICAL DRAFTSMEN on munition work, involving power-plant equipment design, and handling machinery. Good opportunity for men willing to work hard on war work. Location, Delaware. 0172-E.

MECHANICAL ENGINEER with about five years' experience in power-plant construction to act as assistant in connection with construction nitrate plant. Salary, $2,000. Should have deferred draft classification. Location, Alabama. 0174-E.

MECHANICAL DRAFTSMAN experienced in power plant work for position in connection with construction nitrate plant. Should have deferred draft classification. Salary, $1,800. Location, Alabama. 0175-E.

INSTRUCTOR, elementary mathematics and mechanical drawing for apprenticeship school. Candidates should have had some technical training and shop experience and understand the handling of young men. Position offers excellent opportunities for advancement in the works and will pay an initial salary of $1200, or more, according to caliber of man. Location, Connecticut. 0176-E.

TIME-STUDY AND COST-WORK MAN, preferably about 27 years old, with actual experience in routine work for a machine shop doing work of a semi-standardized type, on large engines, not interchangeable; capable of setting times on large machine tools. Must be an American citizen. Salary about $30.00. Location, New York. 0177-E.

EXPERIENCED FACTORY PLANNING DEPARTMENT HEAD required by a New York company employing 2,000 men engaged in the manufacture of a variety of complicated electrical and mechanical apparatus. Applicant must have had at least five years' experience in tool design, routing, and dispatching. Excellent prospect open for the right man. State age, education, experience, salary required, and nationality. 0180-E.

FACTORY MANAGER. A well-known New York company employing about 1,800 men, engaged in the manufacture of a variety of electrical and mechanical apparatus, all covered by its own patents, is in need of an experienced factory manager capable of efficiently organizing and managing the factory department, which includes the following departments: welfare and employment, service and maintenance, planning and production, and a shop operating branch. Excellent opportunity. Write, stating age, education, experience, nationality, and other qualifications. 0181-E.

ASSISTANT CHIEF ENGINEER. A New York company employing about 2,000 men engaged in the development, design, and manufacture of complex electrical and mechanical apparatus for special purposes, requires an experienced assistant chief engineer capable of taking charge of mechanical design, standardization, and drafting, leaving the chief engineer free to devote himself to research, invention, and development. Applicant must be technical graduate with at least five years' mechanical designing experience. Excellent opportunity for an able man, position carries good salary, as well as the prospect of very interesting work and a broad future. State age, education, experience, nationality, and salary required. 0182-E.

DRAFTSMAN, with technical training and sufficient experience to enable him to lay out machinery in new plants, including the making of drawings, covering electric light and power systems. Permanent position. Prefer man with chemical plant experience, or one who has done drafting for consulting engineer. State fully qualifications and past experience. Salary $1,500 to start. Location, Southern Ohio. 0184-E.

MAN capable of taking charge of department employing about 100 men. Must thoroughly understand the bleaching, dyeing, sizing and calendering of cotton goods, a good handler of men. Position would pay about $35.00 per week to start and more after the man was able to demonstrate his ability. Location, near New York. 0185-E.

DRAFTSMEN of general mechanical experience, men of integrity, reliability and industry, with experience in general drafting, design and layout work. State age, details of experience, salary expected and references. Location, Delaware. 0186-E.

BOILER MAN fully conversant with every detail of design and construction of steam boilers, particularly water-tube boilers. Must be willing to make an investment in a progressive boiler shop. Location, New Jersey. 0187-E.

FOUR OR FIVE TECHNICAL GRADUATES to take a standard apprenticeship course covering a period of two years in boiler shop. Location, New Jersey 0188-E.

DRAFTSMAN AND FIELD MAN. Young engineer with knowledge of anthracite colliery practice. Location, Pennsylvania. 0189-E.

PUBLIC SERVICE COMMISSION. Opportunity for several young technically trained men, preferably with some practical experience in mechanical or electrical engineering. Salary, $90.00 per month to start. Give particulars as to age, training, and experience. Location, New York. 0192-E.

SALES ENGINEER AND PURCHASING AGENT, preferably a man with experience in building line. Position requires man of caliber capable of doing purchasing for medium-sized factory and of handling the development of sales program. One not subject to draft or a late number in the draft. Preferably acquainted in and about New York. Headquarters, New York. 0194-E.

SALES ENGINEERS to represent a line of carefully selected power-plant specialties; sale involves a knowledge of their use and adaptation to power plants in general. Necessary that men have more than an outline knowledge of power-plant design, construction, and operation, in addition to ability and knowledge as salesmen. Prefer men with several years' experience as sales engineers. Location, Virginia. 0196-E.

YOUNG MEN, technically trained in mechanical engineering course, to enter engineering department of company manufacturing fluid meters and special equipment. Rapid advancement to outside power-plant engineering work. Location, Boston, Mass. 0197-E.

DRAFTSMEN for proposition department, in power-house and boiler-rooms, and in making estimates of costs, as an aid to sales department. Opportunities for young men of ability are exceptional. Important that men be conscientious and reliable. Location, New Jersey. 0207-E.

TRANSPORTATION ENGINEERS AND EXECUTIVES. Prominent truck manufacturer offers unusual opportunities for several mechanical engineers for organization and development work and to train for executive positions with owners of large truck fleets, the demand for which is only just beginning. The privilege of a short preparatory training at nominal pay is available. Write how qualified and salary expected. Location, New York State. 0208-E.

EVAPORATOR EXPERT. Engineer experienced in designing and selling of evaporating apparatus for large concern desirous of extending their business. Letter should contain detailed information as to past experience, qualifications, and salary expected. Location, New York State. 0210-E.

DRAFTSMAN acquainted with smelting work. Location, Texas. 0211-E.

SALES ENGINEERS for hand stoker. Will pay liberal commission on the gross sales price. Man should have a technical foundation and be familiar with combustion problems. Would expect man to spend two weeks

with organization to gather selling data, facts and operation of the stoker, thoroughly equipping him for work. Location, New England. 0212-E.

SALES ENGINEERS. Air-compressor manufacturer has several openings for locations in various district offices. State qualifications, experience if any, and compensation expected. Location, Illinois. 0216-E.

SEVERAL MEN WITH MECHANICAL ENGINEERING TRAINING wanted in connection with the various operating and test problems in operation of large power plant.

(a) TWO JUNIOR ENGINEERS with experience in test work on various types of power apparatus. Start with salary of $100 per month.

(b) For the shift operating jobs three vacancies. Start with a salary of $150 per month. Numerous opportunities for promotion and men who make good always considered for transfers to other various plants. Location, Virginia. 0217-E.

PLANNING-DEPARTMENT AND TIME-STUDY MEN. Well-established firm can offer exceptional opportunities for effective and interesting work to engineering graduates with substantial experience in modern industrial methods, with special reference to time study, the determination of standard tasks, planning and scheduling production. In reply state age, education, experience, present and expected salary. Headquarters Boston. 0218-E.

POWER-PLANT ENGINEERS. Well-known industrial concern engaged on important work for the Government wishes to engage the services of several power-plant engineers for the construction and operation of large power plants used in connection with important munition production for the Government. A technically trained college graduate preferred, although equivalent training elsewhere will be considered. Executive experience in the operation of large power plants is essential, supplemented preferably by experience in the construction of large power plants and familiarity with design. Practical experience should cover all of the usual forms of central station equipment and also power distributing systems, refrigeration, compressed air, hydraulic machinery, water-pump machinery, etc. Executive ability is most essential, to be combined with the necessary tact to give successful coöperation. Give fully particulars concerning qualifications including age. Please type information on a full-size letter sheet. 0219-E.

COMBUSTION ENGINEERS, with wide experience in the theoretical and practical operation of boilers and stokers; also executive experience in the operation of very large boiler rooms. Location, Delaware. 0220-E.

DRAFTSMAN AND ENGINEER, one well posted on mechanics and mathematics; up-to-date, with boiler-designing experience. State past experience, advising the past and present employers and how long employed by them, education, nationality and salary expected. Location, Chicago, Illinois. 0221-E.

DRAFTSMEN familiar with power station, piping, and piping layouts for a plant for the U. S. Government. Give age, training, experience, and lowest salary that will be accepted when writing. 0222-E.

SALES MANAGER who will keep in touch with production and shop operations and having wide experience in modern power piping. Eastern Location. 0231-E.

SHOP SUPERINTENDENT for small plant manufacturing gas engines and oil well supplies. Location, Okla. 0233-E.

PRODUCTION MANAGER to systematizing shop; small plant manufacturing gas engines and oil-well supplies. Location, Okla. 0234-E.

HIGH-GRADE EXECUTIVE for position as assistant superintendent in factory employing 250 hands, manufacturing duplicate parts. Experienced in handling both men and women employees. Thorough mechanic, experienced in getting work through the shop, operating on a premium basis. State fully in first letter experience, age, nationality, references, salary expected and when available. Location, Ohio. 0235-E.

DRAFTSMAN OR TECHNICAL GRADUATE, mechanical engineer, with one to three years' experience in general mechanical drafting, in an industrial plant. Advise salary expected. Fine opportunity for energetic and original young man. Location, Minnesota. 0236-E.

TECHNICAL MAN experienced in economy and operation of boiler and power-house machinery. Location, East. 0237-E.

TESTING ENGINEER to take charge of testing in steam-turbine manufacturing plant in Western New York. Technical graduate and one with some knowledge of electricity; experienced in handling men. 0238-E.

SUPERINTENDENT, initial qualifications, several years' standing as a technical school graduate, from civil or mechanical engineering course; with energy, good judgment and ability to handle men. 0239-E.

ENGINEER, preferably with field-construction experience or with knowledge of erection work. Salary to start $1800 and good opportunity for advancement. Location, New York. 0240-E.

MECHANICAL ENGINEER AND EXECUTIVE MANAGER for chemical plant. State age, previous employment, salary and when available. Location, New Jersey. 0241-E.

POWER ENGINEER, mechanical and electrical engineer, capable of superintending complete power-plant proposition of cement-manufacturing plant, and of acting as assistant to superintendent of the plant in special study of improvements, fuel conditions, etc. Man 35 to 45. Location, Pennsylvania. 0242-E.

EXPERIENCED ENGINEERING CHECKER. State kind of experience, education, age, nationality and salary. Location, New York. 0243-E.

TOOL AND INSTRUMENT MAKER. Good organizer. Age 35 to 40 years, American born, good personality. Salary, $250. Location, Brooklyn. 0244-E.

EXPERIENCED TOOL DESIGNERS, salary depends on the man. Location, New York. 0246-E.

FIRE PROTECTION ENGINEER. Large plant in Detroit requires man to guard against fire hazards. Should be fully informed as to modern fire-prevention methods, with sufficient training and education in electricity and chemistry to fully appreciate hazards of this sort. In applying, state age, draft status, nationality, extent of education, detailed experience, present employment.

TEACHING POSITIONS. Assistants in mechanical construction and electrical engineering. Location, Rhode Island. 0249-E.

DRAFTSMEN AND CHECKERS. Government work. Location, New York City. 0250-E.

MECHANICAL SUPERINTENDENT for textile manufacturing plant. Salary, $1,800. Location, Rhode Island. 0252-E.

SHOP INSPECTOR, preferably 25 to 35 years of age, familiar with car construction or structural work. Salary about $150. Permanent position for the right man. Location, New Jersey. 0256-E.

MECHANICAL ENGINEER. Excellent opportunity for a technical man with shop and drafting-room experience with a growing concern in Connecticut making high grade specialized product. Work would be interesting and carries with it considerable responsibility. Applicant must give full particulars in answering. 0257-E.

ASSISTANT TESTING ENGINEER, technical graduate, not subject to draft, with experience in steel heat-treatment and testing work, wanted by a growing concern in Connecticut, making a high-grade specialized product; knowledge of chemistry would be an advantage. Good opportunity and work interesting. Applicant must give full particulars in answering. 0258-E.

CONTROLLING INTEREST in prosperous machine-tool and gage-manufacturing concern to be sold for best offer. Present owner to enter service. Well-known firm of wide reputation. Location, Connecticut. 0259-E.

CAPABLE PRACTICAL MAN to take entire business control of machine shop building special machinery, gages and tools. Engineer with business knowledge and experience in this line of work preferred. An interest in the business may be acquired by the right man. Location, Connecticut. 0260-E.

SALESMAN familiar with the sale, design and making of special machinery, tools, gages and fixtures, practical mechanical experience necessary. Good opening for right man. Location, Connecticut. 0261-E.

SALES ENGINEER, (0263-E), technical graduate familiar with automobile starting, lighting and ignition apparatus and electrical devices in general. Experience in plastic molding or die casting would be advantageous.

SERVICE ENGINEER, (0264-E), need not be a technical graduate but should be familiar with die casting and hydraulic press work.

If applicants for the above two positions are between the ages of 21 and 31 they should show cause for exemption or have numbers near the end of the draft call. Prefer a single man since the positions will require considerable traveling over a wide territory. Product is highly specialized and the first two or three months of employment will be spent in the shop and laboratory. Salary commensurate with experience and ability. 0263-E and 0264-E.

COLLEGE GRADUATES, men out at least a year, for general shop-engineering work, leading to industrial-management positions, with growing concern. State full particulars. Location, New Jersey. 0265-E.

SHOP SUPERINTENDENT for company manufacturing high-speed machinery for addressing, folding, wrapping and sealing newspapers for the mail. Man over draft age, must be resourceful; technical education, general rather than too highly specialized experience, with all-round shop experience, in machine tool operation, tooling for production, purchasing, laying out of shop, handling men, shop accounting, rate setting, cost production, estimating. Salary will depend on the individual man, his education, experience and native ability. Location, Chicago. 0266-E.

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 12th of the month, and the form of notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

MECHANICAL ENGINEER, Member, at present professor of mechanical engineering in southern university, desires work for summer. Available from June 10 to September 10. Has had shop and drafting-room experience, familiar with design of steam pumps, locomotives, and heating and ventilating plants, also building construction. E-118.

MECHANICAL ENGINEER, American, 14 years' practical experience in the manufacture of engineering specialties, machine tools and shop equipment; also power, machinery and shop maintenance, oxy-acetylene, welding, drafting, physical and experimental department. Familiar with brasses, iron and steel. An executive with initiative and aggressiveness. At present employed. Will go any place. Salary, $2800 and expenses. E-119.

ASSOCIATE-MEMBER, can furnish the best of references. Consider permanent position with a strong company. Salary, $2500 to start. Age 32, married. E-120.

MECHANICAL ADVISER AND DEVELOPMENT ENGINEER. Special-machine designer, policy investigator, practical and technical education, good organizer and systematizer. Specialist on mechanical efficiency operation. Expert on substituting mechanical devices for hand labor. Past 15 years specializing on designing, developing and manufacturing up-to-date cost cutting appliances, special equipment, tools and labor-saving devices for manufacturing special product efficiently. Age 35. Assoc. Mem. Salary, $4800. Desire new connections with large corporation contemplating improving or redesigning its present manufacturing methods where above experience is essential. Location, vicinity Newark or New York City. E-121.

GRADUATE ENGINEER, with ten years' active and consistent experience in the practice of principles of industrial management, is not an efficiency engineer or cost clerk. Will associate himself with a bank as industrial expert or with a large manufacturing enterprise as confidential assistant to president or manager, or will take charge of an executive department but not below works manager. Available July 1. E-122.

MECHANICAL ENGINEER desires position with concern in Philadelphia or California. Technical knowledge, drafting and shop experience. Age 36. Married. Full particulars on application. E-123.

PLANT MANAGER. Executive of proven ability, having wide experience in large factory management. Broad-minded with all-round mechanical training and practical knowledge of production methods. Investigate. Your time will not be wasted. Salary expected, $7500. E-124.

MECHANICAL ENGINEER AND EXECUTIVE. Technical graduate, 39 years of age. Six years' experience in design, construction and operation of ore concentrating plants. Six years' experience in sale and manufacture of ore-concentrating machinery, including thorough study of shop production and management. Employed, but desires responsible position with large mining corporation or with company handling government work and needing men of above qualifications. E-125.

MECHANICAL ENGINEER, CHILE, S. A. Technical graduate, M. E., 1911, married, age 30, American, with 7 years' experience in design along hydroelectric and mechanical lines. At present chief draftsman on construction work for large American mining concern. Available September 1. E-126.

EXECUTIVE, MANUFACTURING AND MECHANICAL. Desires to locate in Connecticut. Has wide experience in the manufacture of interchangeable parts for munitions and general hardware. E-127.

MECHANICAL ENGINEER. Member, age 40, American, 22 years' experience on automatic machinery, automatic press tools and deep-drawing press work, 12 years' experience in Connecticut brass shops, and ten years with present employers. Can design, supervise, organize or install new work as mentioned above. Present employer best recommendation. E-128.

JUNIOR MEMBER, expert in machine design, and a good all-around draftsman, desires part time work outside of regular position. E-129.

EXECUTIVE AND PURCHASING ENGINEER, Boston graduate, member, age 40, married, American, 20 years' experience covering the construction, operation, and maintenance of the estimation, appraisal and purchase for manufacturing plants. At present employed as assistant chief and purchasing engineer. Location preferred, New York City. E-130.

COMBUSTION ENGINEER. Associate-member, mechanical engineering graduate, age 30, married, in class IV of the draft, with five years' experience in the combustion of a variety of different American fuels, testing, investigating, designing and economy work, familiar with stokers, and different types of hand-fired furnaces both in high- and low-pressure work. Good record. Capable of responsible work. Only permanent positions considered. Minimum salary $2700. E-131.

MECHANICAL AND ELECTRICAL ENGINEER. Member, Cornell graduate. About twenty years' experience in general engineering and at present chief engineer for a company operating four manufacturing plants. Familiar with conveying, elevating, crushing, combustion, heat balances, testing and gas and steam problems. Highly recommended by present employer. Minimum salary $3000 per annum. E-132.

MECHANICAL ENGINEER, member, technical education, age 40. Sixteen years' experience with two large corporations on construction, power-plant operation, and maintenance work, desires new connections as mechanical engineer in charge of engineering department, with medium- to large-size industrial plant. E-133.

SALES AGENT, mechanical engineer, technical graduate, thirteen years' experience in selling, designing, and estimating, desires to represent high-class manufacturer in New England territory with headquarters in Boston. Best of references. E-134.

CHIEF ENGINEER OR MASTER MECHANIC, with thorough technical and practical experience, covering construction, operation, and upkeep of steel plant. Specialty, metallurgical work, heating and melting furnace. E-135.

SAFETY ENGINEER, with six years' thorough technical and practical experience in this capacity, with large steel works in Pennsylvania. E-136.

PRODUCTION MANAGER, experienced on aeronautical engines and parts and high production on light-weight machinery, desires position as executive on Government work. Expert tool designer; experienced in shop efficiency and cost recording; understands all classes of automatic-machine work, including sheet-metal stampings. Salary about $300 a month. E-137.

MECHANICAL ENGINEER, Member, technical graduate, age 39, desires position as engineer or chief draftsman. Expert in design of high-power hydraulic turbines, governors, etc., also shop practice, layout of power plants and design of general machinery. One year's experience in a testing laboratory for machinery and material. E-138.

WORKS MANAGER OR GENERAL SUPERINTENDENT. Member, American, age 50, married. Thirteen years as superintendent and works manager of company manufacturing superheaters and other power plant specialties. A thorough understanding of gray-iron foundry, forge, and machine-shop practice. Has originated and developed machines and tools and proved good organizer and executive; previous experience as erecting engineer of hydraulic machinery. Desires position with growing concern. References. E-139.

ENGINEER, experienced in estimating, correspondence and sales, and in responsible charge of important work, for general machinery, pneumatic, pumping and pipe work. Age 33 years. Associate Member. E-140.

ASSISTANT PROFESSOR in mechanical engineering qualified by experience as a teacher and as an engineer. Well recommended. E-141.

WORKS ENGINEER, with twenty years' experience on engineering and scientific production; thoroughly versed in drafting, inspection, routing, rate setting, maintenance, tools and special machinery; age 40. E-142.

EXECUTIVE, Member, age 42. Present position 13 years. Manufacturing, drafting, construction, estimating and sales experience. Minimum salary $5000. Location New York. E-143.

MECHANICAL-ELECTRICAL ENGINEER, technical graduate with fifteen years' experience. Thoroughly familiar with engineering construction and operation of power stations and sub-stations. At present assistant superintendent with large public service corporation. Desires position as superintendent or mechanical engineer with direct responsibility and opportunity to expand. E-144.

EXECUTIVE OFFICER of leading industrial corporation, American born citizen, 48, graduate mechanical engineer, 25 years' manufacturing and business experience in this country and in Europe, as works manager, sales manager (domestic and foreign) and subsequently as general manager and managing director of European subsidiary company employing 3000 men, with headquarters in Paris. Recently returned to this country, on account of war conditions, and at present is employed as manager of corporation's foreign business. Desires position of responsibility in executive or selling capacity, offering opportunity to produce results. Highest New York and Pittsburgh references. E-145.

ENGINEERING SURVEY

A Review of Engineering Progress and Attainment in Mechanical Engineering and Related Fields, Including a Digest of Current Technical Periodicals and Selected Titles of Engineering Articles

Boston Society of Civil Engineers

At the last annual meeting of the society Prof. George C. Whipple, of the Civil Engineering Department of Harvard University and the Massachusetts Institute of Technology, delivered a presidential address entitled The Engineer as a Social Force in the New Democracy.

In recent years our forecasting of the future has been on a mathematical basis largely, but the problem has now changed to a social one. The new problem is political and ethical rather than physical and mathematical, and the engineer must join the other professions in the effort to solve this problem.

As regards the effects of the war, Professor Whipple expressed his belief that a readjustment of political and social conditions throughout the world is inevitable and that peace and tranquility will not come until these great questions are settled. After the war the great problems of the day will be social problems, and the engineer must play his part in them.

One social problem, as a result of the war, will be that of rewards. Labor is going to demand its share, and the engineer, who acts as intermediary between labor and capital, will be needed to solve the problem. Another great opportunity is offered the engineer for being a social force in the world, namely, to bring about harmony between the work and the worker. Just as the engineer is now the inspector of the work performed, he should also be the inspector of the men who perform the work.

The speaker called attention to the present opportunities for engineering work in foreign fields and declared that the engineer must henceforth think in terms of the world.

San Francisco Association of Members of the American Society of Civil Engineers

At a recent meeting of the association the subject of discussion was, "Why Have Not Engineers Achieved Higher Rank Among the Professions?" Seven members had been asked to prepare short talks on the subject and a committee was appointed to study and bring in recommendations on the various suggestions. The *Engineering News-Record* for March 28, 1918, reproduces some parts of the report of this committee.

There was a consensus that engineers should broaden their general knowledge of affairs; that in addition to a mastery of the technical side of engineering they should cultivate the ability to speak and write well, and after graduation endeavor to broaden by contact with other men, by taking part in civic affairs and by striving to develop administrative and executive ability.

Both the public and the engineer would benefit, it was held, if engineers were more active in public affairs and had a higher professional standing in the eyes of the public and the other professions. If a change in the status of the engineer is to be brought about, engineers themselves must take the initiative. The question then becomes, "What action is desirable?"

The first step, the committee believed, is to establish clearly just what kinds of engineers are being considered and what distinguishes one class from another. The term "engineer" or even "civil engineer" is too broad to constitute a classification. As a starting point, therefore, the committee suggested three classes: (1) Those who plan or design, (2) those who assemble or erect, and (3) those who manufacture or sell.

In other professions, it was pointed out, there are sharp lines of demarcation; the architect is not easily confused with the builder or with the manufacturer of building materials; the profession of the physician is distinct, and excludes the druggist and the chemical manufacturer. But civil engineers have not taken pains to establish such distinctions. Commercial activity has become so closely identified with professional activity in civil engineering that even those involved have difficulty in drawing the line. The layman is naturally less able to do so and therefore a "civil engineer" is generally thought of as a man with more or less specialized training, engaged in a technical phase of commercial activity.

The committee pointed out the need for further study along this line so that there could be an agreement on definition and classification. Objectives particularly desirable, it was believed, are (1) an up-to-date definition of what constitutes a civil engineer; (2) an up-to-date definition of a consulting engineer; (3) the classification of civil engineers professionally into the three groups suggested, and (4) a statement of ethics or standards by which these classifications shall be established.

Aeronautical Society of America

An open meeting was held in the auditorium of the Engineering Societies Building, April 4, at which the first report of the investigating committee of the society was presented.

After an investigation of several months the committee found a good many features in the execution of the American aircraft program to which objections were made—such as exaggerated statements of what has been accomplished; and excessively rigorous censorship, which, in the view of the committee, has interfered with production and precluded effective coöperation with the Government on behalf of the American engineering profession.

As regards the Liberty motor, it was stated that there is no doubt as to its being a good design, but that the production of the motor has been unnecessarily delayed by constant changes. From all information available it appears that while the low-compression low-altitude type may be considered as being developed to such an extent that with proper effort it can be turned over to standardized production in a comparatively short time, the development of the high-altitude type is still in its infancy.

Considerable space is devoted to the discussion of the state of research and invention in connection with the development of the aviation program. It is stated that the actual situation is as follows:

The entire matter is partly in the hands of the Signal Corps and partly of the National Advisory Committee for Aeronautics. The Signal Corps has somewhat over $2,000,000 avail-

able for this purpose and is doing work of a very high grade at the McCook Field, Dayton, Ohio, but the facilities available and the number of men employed are entirely inadequate for the tremendous program of the country.

Likewise, a good deal of research is being done at the Bureau of Standards, chiefly in connection with development of the Liberty motor. Here, again, the work is of the highest grade, but the staff is small and the facilities limited to such an extent that only matters of the most vital importance can be carried out.

The National Advisory Committee was organized long before the United States entered into the war, and consists of a few men who have many other and onerous duties to perform. The committee has at its command no laboratory facilities for testing out inventions and no organized technical staff for their consideration. The appropriation asked by the committee for the next year is only $260,000, an amount entirely inadequate for properly handling inventions affecting the program which may easily run into several billions of dollars.

The investigating committee suggested that the National Advisory Committee for Aeronautics be reorganized into a modern and adequate body with ample laboratory facilities and a staff of men who would devote their entire time to the consideration of new inventions. An adequate appropriation of something like $25,000,000 should be granted to the committee.

Representative John Q. Tilson, of Connecticut, in discussing the report, stated that he, as well as the Aeronautical Society of America, had only an attitude of extreme friendliness to the Aircraft Administration. He ascribed at least some of the delays in the execution of the program to two causes: First and foremost, the fact that the production, which is a purely industrial problem, was placed in the hands of the Army, which means men who, however highly fitted for the performance of their direct duties, were not equipped with the knowledge and experience necessary to handle the great and noble problems involved in putting through the construction of machines running into something like a billion dollars. Men have been called from the outside, from the industries, but they were put into uniforms, and in this way made subject to orders from men who, while superior to them in military rank, knew far less of the direct industrial problems involved. Machine construction ought to be in hands of captains of Industry, and not majors and captains of the Army.

The other cause of delay, of considerably lesser importance, was the constant desire to improve things and the delays due to tinkering with designs, which, in many cases, have already proved their worth abroad. Representative Tilson expressed his conviction that the aircraft program in particular, and the munitions program generally, are practically at the end of their past errors and that new and startling results on a really big scale may be expected.

A more complete abstract of the report of the investigating committee will be found in the *Iron Trade Review*, April 11, 1918. A practically complete report of the addresses at the meeting was published in the *Air Service Journal*, April 11, 1918.

German Textile Use of Nettles

Stinging nettle fiber as raw material for the textile industry is in use in a varying degree in Germany, Austria, Denmark and Switzerland as a result of the shortage of cotton caused by the war.

The British Board of Trade, which has been watching the progress in the use of the nettle, has issued a report, calling attention to the danger of ignoring a substitute which may become a serious competitor with staple industries before the full extent of the risk has been appreciated. Believing this to be the case with the stinging nettle, and hoping to make Germany independent of supplies of foreign cotton, the Germans have studied, tested and adopted it as a war necessity.

Large quantities were collected in the summer of 1916 under the provision *Nessel faser Verwertungsgesellschaft*, the new German war company, holding an exclusive right to purchase, if necessary by compulsion, all stems of stinging nettles (*Urtica Diocia*), whether native or imported. This company claimed that a tissue was obtained from the fiber comparing favorably with that manufactured from American cotton. When mixed with wool, a cloth of soft texture, resembling expensive woolen material, but much cheaper and easily dyed, is said to be produced, although this claim is not confirmed. By adding flax, cloth of other characteristics is obtained.

In Denmark, a government committee experimented with nettles, paying for them at the rate of 7 kroner per 100 kilograms. For textiles, only the fibrous part of the plants is necessary, and the committee favored the putrefaction method of separating this from the rest of the nettle. The main points of this method are:

1 The nettles are harvested in September and October, and are stacked like straw through the winter
2 Tops and leaves are removed
3 Stalks are rotted either (*a*) in a "rotting dam," consisting of a wooden cage sunk in a lake or other natural water, or (*b*) in hot water. The former process takes fourteen and the latter four days with the water at a temperature of 30 deg. cent. Experiments are still continuing to define the correct heat and time
4 Stalks are dried in the open air
5 Stalks cracked in a breaker
6 Stalks teased on a teasing board with a wooden knife
7 Fiber combed through a large iron comb or hackle, which finally removes all the remaining wood.

The fiber is then ready for the ropewalk or the spinning.

One of the difficulties of the putrefaction process is the presence of bacteria. Two prevalent sorts have been discovered, a beneficial and a harmful. It is said the harmful species can be removed by steeping the nettles in running water for two or five hours before commencing to treat them. Experiments are being conducted in the pure cultivation of these bacteria with a view to finding a simpler method of putrefaction. (*Journal of Commerce*, March 22, 1918, pp. 2 and 13.)

Course to Train Drafted Men for Technical Employments

A war-emergency course to train conscripted men for machine-shop occupations, blacksmithing, sheet-metal working, and pipe fitting, has been prepared by the Federal Board for Vocational Education and will be distributed to the schools throughout the country as soon as it can be printed. It is known as Bulletin No. 8.

"There is a critical and constantly growing need for many thousands of mechanics and technicians for Army occupations carried on in and behind the lines of the United States Army," declares the Board of Vocational Education. "Many of these workers, already experienced in similar occupations of civil life, will be secured through the draft and possibly through voluntary enlistment. It is recognized by those in a position to know that the quotas thus obtained will not be sufficient, and that it will be necessary to give special train-

ing to many thousands of men for various occupations and in various ways. The War Department has taken definite steps to provide for this training systematically through Army schools and in some instances at cantonments, but largely at the industrial trade, and engineering schools of the country."

The Federal Board for Vocational Education is acting for the War Department in preparing these courses of study and in dealing with the State authorities in charge of the school work. Men who take these courses, it is declared, "should not be led to believe that they are learning a trade. They are serving their country by learning to do a special job well, though to some extent this training may be beneficial to them in after life." (*Official Bulletin*, March 29, 1918, p. 7)

International Air Traffic Company

According to the *Neue Freie Presse*, January 4, a new company has been formed in Austria-Hungary styled the International Air Traffic Company (Internationale Luftverkehr-Aktiengesellschaft, abbreviated "Ilag"). It is intended that the "Ilag" shall at first undertake the conveyance of letters and parcels on the route Hamburg-Berlin-Dresden-Vienna-Budapest-Belgrade-Sofia-Constantinople. From points in this main line numerous branch lines will run to the most important cities and traffic centers of Germany and Austria-Hungary, so that, according to present intentions, the whole of Central Europe will be covered, at no very distant date, with a close network of air lines. Passengers will be carried as well as postal matter.

Steps are to be taken to form separate companies in Austria and Hungary. The promoters are in touch with interests in Germany, so that there, too, a company will shortly be formed in close connection with the Austrian and Hungarian enterprises. The Austrian and Hungarian post-office administration, even before the war, had begun negotiations for a contract for postal dispatch, which can only be definitely concluded when the "Ilag" is ready to commence its service; negotiations, however, with municipal authorities have already commenced there with a view to providing landing places suitably equipped in all the towns covered by the new air service.

Meanwhile the legal committee of the Hungarian Aero Association has made an agreement with the Austrian Aero Club and the Imperial German Aero Club of Berlin that the contemplated interassociation conference for the purpose of establishing uniform laws for the air, to which those in Bulgaria, Turkey and Poland interested in the matter, are to be invited, shall take place in Budapest in the second half of 1918. (*Christian Science Monitor*, March 20, 1918, p. 9.)

The New U. S. Enfield Rifle

The Chief of Ordnance authorizes the following:

American troops are armed with a faster-firing and more accurate rifle than used by the Germans, according to our expert designers, manufacturers and marksmen.

The superiority claimed for the American weapon is supported on three counts: 1, quicker firing as a result of bolt-handle design; 2, easier and quicker sighting as a result of sight design; 3, greater accuracy of bullet flight as a result of bullet design, and greater mechanical accuracy of chamber and bore. Each of these points is explained hereafter.

In both the attack and the defense of trench position the rifles are fired without removing them from the shoulder at a rate called "rapid fire," which is the most rapid rate of magazine fire consistent with quick accuracy.

When the Mauser rifle, with which the German troops are now armed, was designed in 1898, no one could foresee the development of "rapid fire" from the shoulder which followed, and the necessity for which is emphasized by present-day trench warfare.

In all modern rifles a "bolt handle" is used to lock the carriage in the chamber for firing. After each shot the right hand must leave the trigger, grasp the bolt handle, eject the empty shell, thrust home another cartridge—all done by movements of the bolt handle—and then push the bolt handle into the position which again locks the cartridge chamber. Thus the position of this bolt handle in reference to the trigger is of great importance to rapidity of fire.

The Mauser rifle has the bolt handle projecting horizontally from the rifle so that, in locking the bolt for firing, the index or trigger finger is left several inches above the trigger.

In the United States rifle (model of 1917, popularly called the modified Enfield) the bolt handle is bent not only down, but also an inch to the rear so that upon locking the bolt for firing the index finger is guided naturally into position for firing. This feature was adopted from the British Enfield rifle, model of 1914, as made in America for Great Britain. The speed of firing thus gained is considerable. (*Official Bulletin*, March 21, 1918, p. 13)

Proposed Screw-Thread Commission

A bill is now before the House of Representatives, introduced by Representative John Q. Tilson, of Connecticut, to establish a national standard of screw threads. In the record of the House was placed, among other arguments, a strong plea for the enactment of the bill forwarded by Calvin W. Rice, Secretary of The American Society of Mechanical Engineers. The early passage of this legislation was urged by all the witnesses, several of them declaring that the entire munition production program of the United States had been seriously delayed through lack of standardization, and especially because of the failure of various Government departments and manufacturers to reach an understanding as to screw-thread tolerances.

The bill, as reported, provides that the commission shall be composed of the Director of the Bureau of Standards, who shall act as chairman, one commissioned officer of the Army and one of the Navy, the remaining two members to be appointed by the Secretary of Commerce, one of whom shall be chosen from nominations made by The American Society of Mechanical Engineers, and the other from nominations made by the Society of Automotive Engineers. It may be the duty of the commission to ascertain and establish standards for screw threads, which shall be submitted to the Secretaries of War, the Navy and Commerce for their acceptance and approval. Such standards as are thus accepted and approved "shall be adopted and used in the several manufacturing plants under control of the War and Navy Departments, and, so far as practicable, in all specifications for screw threads in proposals for manufactured articles, parts and materials to be used under the direction of these departments." The Secretary of Commerce is directed to promulgate all such standards for use by the public and cause the same to be distributed as a public document. The members of the commission are to serve without compensation. The bill imposes no penalty for failure to conform to the standard established, and it is believed that no other consideration is necessary to induce manufacturers to accept the standards that have been adopted by the Government and will be enforced as to Government contracts. (*The Iron Age*, April 4, 1918, pp. 870-871.)

This Month's Abstracts

Two papers abstracted in this issue deserve especial mention. First is a paper by Harold Jeffreys in the *Philosophical Magazine* presenting a mathematical treatment of the problem of evaporation. The writer treats it as one of gaseous diffusion and derives an equation for evaporation identical in form with those that determine the transference of heat and momentum. In fact, an equation is derived where, for the case of transference being due to turbulence only, the coefficient k has the same value in evaporation as it has in transference of heat and momentum. This gives a definite physical meaning to the phenomenon of evaporation that may prove to be of great interest for the inverse question of condensation of vapors and drying of air.

Another paper of great interest is one by Albert E. Guy in the *Journal of the American Society of Naval Engineers.* In discussing the lateral flow of water under low heads the writer, among other things, shows that the so-called varying flow-head theory is untenable and also that the usual assumption that the pressure within the jet in the case of flow through a thin-plate orifice is atmospheric, is erroneous, and the common practice in measuring the flow through a horizontal orifice by means of the pitot tube with the pointed end of the tube placed along the horizontal diameter is wrong with such heavy fluids as water, since it results in showing a velocity and consequently a volume greater than the actual. A rather novel theory is offered to explain the generation of the velocity of flow of water issuing from a container through a lateral orifice into the atmosphere.

Fundamental systems for steam-turbine alternators are discussed from a practical point of view. Among other things is given a formula for the loss on static head equivalent to the resistance to the passage of air through a round or square sheet-metal air duct.

The use of spruce in aeroplane construction is considered on the basis of tests made by the Forest Products Laboratory of the Forest Service, including the relation of shrinkage to specific gravity. In this connection the tests have proved that spruce tends to show a greater shrinkage in heavier pieces than in light pieces, and as a result of this pieces of low weight are likely to cause less trouble from shrinkage than the heavier and stronger pieces.

Substitutes in the German electrical industry are briefly discussed in an abstract from a British publication.

In the section Evaporation two tests are reported from the *Journal of the American Society of Naval Engineers,* one of a Reilly multicoil evaporator and the other of a "jetflo" regenerative evaporator. The tests on the latter are reported in some detail.

Jean Rey, in the *Proceedings of the French Academy of Sciences,* presents a paper on the entropy diagram of gasoline. The interesting part of this paper, which will be more fully abstracted in an early issue, lies in the fact that the thermal properties of gasoline appear to be directly opposite to those of water. For example, the saturated vapor of ordinary gasoline is superheated through fall of pressure.

The engines of the German "Gotha" biplane are described with their half-compression gear. The water pump and the air pump are also described and illustrated.

Annealing by muffle and pot ovens is discussed in a paper by Joseph B. Deisher. Among other things the writer emphasizes the great importance of maintaining a proper rate of cooling, particularly where it is desired to complete the annealing process in the shortest time possible.

A new pressure table for Eley lead crushers is discussed on the basis of the discovery made by H. W. R. Mason: namely, that lead crushers have the capacity of self-annealing, which is a function of the degree of decrement (or degree of resistance developed) and of time. This discovery, which is of immediate interest of course to manufacturers of munitions, may also prove of a much wider interest in view of the fact that the whole subject of the physical properties of lead is likely to undergo a profound reconsideration in the near future. Thus, it has already been stated that the accepted value of the atomic weight of lead may have to be changed and that possibly lead may have more than one atomic weight.

The influence of winter temperatures on locomotive capacity is discussed by W. L. Bean, Mem.Am.Soc.M.E., who states that a drop in temperature decreases the capacity of the boiler and also greatly increases the train resistance, because of the increase of journal friction with the increase in the viscosity of the lubricant. In this way cold weather appears to cut down the efficiency of train operation at both ends. The writer gives an interesting table showing the number of engines which would have to be added in a normal December and a normal January to make up for the loss of operating efficiencies due to winter temperature as compared with summer conditions.

In the section Research special attention is called to the description of the aerodynamic laboratory of the Leland Stanford Jr. University by Prof. Wm. F. Durand, Mem.Am.Soc. M.E. Some of the instruments in this laboratory have been developed especially for aerodynamic work, and the laboratory promises to become an important auxiliary for the testing of design factors of aeroplanes. The equipment for testing of air propellers appears to be especially complete.

A description of an installation where an air heater is provided for each boiler is abstracted from a British publication.

From *The Iron Age* is abstracted an article describing and illustrating a novel type of boiler baffles made of a refractory composition shipped in plastic condition and having a coefficient of expansion so small that the shape of the baffle practically does not change through variation of temperature. It is claimed that this permits of securing a highly airtight baffle.

An abstract of an article in *Power* gives particulars of a modified method of handling boiler pumps devised to prolong the average life of economizers. In this case the arrangement is such that all economizers get the water from the primary heater at a low operating pressure, the pump being in two stages as shown in the illustration.

"Torcrete" is a reinforced concrete specially prepared for ship construction and is said to bear about the same relation to ordinary concrete as rolled steel does to cast iron. Instead of being poured in forms the materials are shot in place by means of compressed air with the "tector," a new type of concrete blower. The processes are the invention of a Mr. Weber. The preparation is discharged on layers of steel fabric or wire mesh, and there may be as many layers as is necessary to produce the required thickness, the layers themselves massing with one another so as to form a perfect solid. It is claimed the torcrete vessels are lighter than wooden ships, built in shorter time and at lower cost than any other type of concrete ships, and that the method of construction is adapted to any size of craft or any form of metal that may be desired. A vessel of 3200 tons displacement has been contracted for by the Southern Oil and Transportation Company. (Philadelphia *Public Ledger*, April 6, 1918, p. 17)

REVIEW OF ENGINEERING PERIODICALS

SUBJECTS OF THIS MONTH'S ABSTRACTS

FUNDAMENTAL SYSTEM FOR STEAM-TURBINE ALTERNATORS
RESISTANCE TO FLOW OF AIR IN SHEET-METAL DUCTS
AIR-COMPRESSOR TESTS
SPRUCE IN AEROPLANE CONSTRUCTION
SPRUCE, RELATION OF SHRINKAGE TO SPECIFIC GRAVITY
ACID-RESISTING IRON
MAGNESIUM ALLOYS IN AMERICA
SUBSTITUTES IN GERMAN ELECTRICAL INDUSTRY
CONDENSER-TUBE FAILURES
THEORY OF EVAPORATION
REILLY MULTICOIL EVAPORATOR TESTS
JETELO REGENERATIVE EVAPORATOR TESTS
DIE CASTING OF ALUMINUM BRONZE
COMBUSTION CHARACTERISTICS OF COAL
ENTROPY DIAGRAM FOR GASOLINE
LATERAL FLOW OF WATER UNDER LOW HEAD
GERMAN "GOTHA" BIPLANE ENGINES
HALF-COMPRESSION GEAR ON MERCEDES ENGINES
STANDARD SPECIFICATIONS FOR LUBRICATING OILS.
VALVE CAMS
ANNEALING BY MUFFLE AND POT OVENS
SWITZERLAND, MANUFACTURE OF MACHINE TOOLS IN
ERICHSEN TESTS OF ALUMINUM SHEETS
MECHANICS OF ROLLING SUPPORT
PRESSURE TABLE FOR ELEY LEAD CRUSHERS
CIRCULATING PUMPS ON U. S. BATTLESHIPS, TESTS
WINTER TEMPERATURES AND LOCOMOTIVE CAPACITY
RESEARCH, PURE SCIENCE AND INDUSTRIAL
AERODYNAMICAL LABORATORY OF LELAND STANFORD JR. UNIVERSITY
HEAT BALANCE, AMMONIA COMPRESSION SYSTEM
AIR HEATERS ON BOILERS
BOILER BAFFLES OF PLASTIC MATERIAL
CHARTS

For Articles on Subjects Relating to the War, see Aeronautics, Engineering Materials, Machine Tools, Munitions, Varia

Aeronautics (See also Internal-Combustion Engines and Engineering Materials)

THE THEORETICAL BASIS OF MODEL STRENGTH TESTS FOR AEROPLANE STRUCTURES, W. L. Cowley, and H. Levy. *Engineering*, vol. 105, no. 2722, March 1, 1918, pp. 219-221. (to be continued.)

POINTS IN BRITISH AIR POLICY. *Automotive Industries*, vol. 38, no. 14, April 4, 1918, pp. 676-679. Based partly on a debate in the House of Commons on February 21 and also on articles in British medical periodicals. The most interesting part of it is that referring to medical attention to air pilots and influences affecting them in flight.

THE AIR FORCE ESTIMATES. *Aeronautics*, vol. 14, no. 223 (New Series) February 27, 1918, pp. 194-199. Same as the preceding abstract, with the difference that the text of the debate is given more completely.

AEROPLANE'S PARTS AT A GLANCE. *Aerial Age Weekly*, vol. 7, no. 1, March 18, 1-18, pp. 52-53, 3 figs.

THE RECENT AND FUTURE GROWTH OF AERIAL LAW; Lecture I, National and Imperial Laws, Dr. H. D. Hazeltine. *Aeronautics*, vol. 14, no. 230 (New Series) March 13, 1918, pp. 230-231.

Air Engineering (See also Steam Engineering)

VENTILATION SYSTEMS FOR STEAM TURBINE ALTERNATORS, E. Knowlton and E. H. Freiburghouse. In modern turbo-generators as much as six times (or possibly more) the power is secured from a pound of material as was in the first large units. This means that proportionate quantities of heat must be dissipated per pound of material, and to prevent serious rise in temperature special means of cooling are necessary. For turbo-generators some sort of forced ventilation is usual.

The quantity of air required for cooling the generator depends on several factors in design, but in general varies approximately with the total losses of the machine minus those in the bearings.

The usual arrangement is that the air passing through the generator may be admitted and discharged wholly outside the turbine room or wholly inside, or partly inside and partly outside. This allows considerable control of generator and turbine-room temperatures throughout the year, and during the coldest weather the air that is passed through the generator may be admitted from and discharged inside the station. A suggestion is made to use the heated air discharged from the alternator for combustion under the boilers.

The design of air ducts is carefully analyzed and formulæ given. The difference in pressure expressed in inches of water necessary to pass the air through the duct is expressed as the loss in static head, the duct being assumed to be round or square sheet metal. This loss is then

$$H = [a + b + (c/39)]H_v$$

where H_v = the velocity head
a = the number of right-angle turns
b = the number of abrupt reductions in area
c = the length of duct ÷ diameter of duct.

Attention is called to the importance of maintaining the alternator and ducts free of dirt. In view of the fact that little data are available on the difference in operating temperature between a clean and a dirty machine, the following results of two tests on machines in commercial service are of interest. The loads were the same under both conditions:

	Dirty	Clean
Machine 1—Rise of armature winding, deg.	54	37
Machine 2—Rise of armature core, deg.	54	41

For cleaning the air an air washer is claimed to be preferable to screens. But if an air washer is used, it is quite important that all free or entrained water be removed from the air before it leaves the washer. The operation with air washers is discussed in detail. (*General Electric Review*, vol. 21, no. 4, April 1918, pp. 240-246, 5 figs., 5 tables.)

TESTING AN AIR COMPRESSOR, Walter S. Weeks. Data of tests of an air compressor as carried out at the University of California for the purpose of giving an answer to the following two questions: How much does the compressed air cost? and is the compressor doing all that it should? In the course of this investigation a highly interesting chart of nozzle discharge was developed.

The paper suggests that all makers of air compressors should agree on a standard method of testing, and it is further suggested that a compressor be guaranteed with respect to horsepower input per 100 cu. ft. of air delivered, with the way of measuring the air carefully determined. (*Mining and Scientific Press*, vol. 116, no. 14, April 6, 1918, pp. 479-482, 2 figs.)

Engineering Materials

THE USE OF SPRUCE IN AEROPLANE CONSTRUCTION, J. A. Newlin. The paper presents data obtained by the Forest Products Laboratory of the Forest Service. It gives some

general information relative to the species and conditions of growth of spruce, the influence of moisture conditions on aeroplane stock, and the relation of density to moisture content, shrinkage and strength. As density is recommended as the best criterion of strength qualifications, methods of determining density or specific gravity are included.

Spruce follows the general law of timber in regard to strength properties and weight: namely, all the strength values increase in proportion to the specific gravity. Two curves are given showing the variation of modulus of elasticity and maximum crushing strength with changes in specific gravity. It is found, among other things, that clear wood with specific gravities of 0.33 (based on value when green) or over 0.36 (when based on oven-dry value) would seldom run below 4500 lb. per sq. in. in modulus of rupture or below 2000 lb. per sq. in. in maximum crushing strength along the grain when green. Drying to the condition of aeroplane stock would increase these minimum strength figures to about 8000 lb. and 4000 lb. per sq. in., respectively.

The conditions of moving material at the aeroplane factories are such that there must be of necessity a wide variation in the moisture content of machined material, the factors affecting this moisture content being: variations in the original moisture content, position of the specimen in the pile or conditioning chamber, and the difference in density of individual pieces which cause them to dry at different rates. It has been generally observed that of two pieces of the same species but different in density, the lighter piece will dry the more rapidly. The laboratory observations lead to the belief that a variation of as much as 10 per cent in the moisture content of the material as it goes through the machine may be expected, although no data on this point are available.

The relation of shrinkage to specific gravity is given in the form of a chart, the law in this case being expressed as a straight line.

Good spruce may be assumed to shrink about 12.5 per cent from the green to the oven-dry condition. Were the material allowed to stand for several weeks at approximately the humidity condition of the assembling room before manufacture, it would probably all arrive at about a uniform and suitable moisture content, but under the forced conditions which exist, it is safe to assume that the better pieces of machined timber frequently have at least 5 per cent more moisture than they will ultimately have. This change of 5 per cent moisture, which may occur between the time of machining the part and its final use, might cause a reduction in one dimension of nearly 2 per cent and in the other of nearly 5 per cent, an amount of change sufficient, for example, in a built-up propeller to split and twist it.

An important part brought out by the tests is that spruce tends to show a great shrinkage in heavier pieces than in light pieces. Consequently, pieces of low weight, which would be considered of low quality, would not cause so much trouble from shrinkage as the heavier and stronger pieces. Hence, by throwing out material on account of a very slight undersize, except where the dimensions are taken immediately after machining, higher-quality pieces are likely to be excluded. (*Aerial Age Weekly*, vol. 7, no. 3, April 1, 1918, pp. 162-163, 3 figs., *ep*)

ACID-RESISTING IRON. Brief abstract of a paper read by Sidney J. Tongay before the London Section of the Society of Chemical Industry on March 4.

The paper discussed in detail the troubles encountered in making acid-resisting iron, due to its great shrinkage and the possibility of some of the compounds separating out during process of cooling and forming eutectics. Some tests recently made at the Manchester School of Technology showed that these eutectics consist largely of phosphorus and silica. These difficulties were largely overcome by suitable furnaces and improved manipulation in mixing the metal.

The paper gives the physical constants of acid-resisting iron as compared with cast iron. The heat-transmitting power of acid-resisting iron has been calculated at ten times that of stoneware or quartz, which makes it possible to make the parts much smaller. (*The Practical Engineer*, vol. 57, no. 1620, March 14, 1918, p. 127.)

A BIBLIOGRAPHY OF ALLOYS, Clarence Estes. *Metallurgical and Chemical Engineering*, vol. 18, no. 6, March 15, 1918, p. 312.

RAPID GROWTH OF AMERICAN MAGNESIUM INDUSTRY. *Metallurgical and Chemical Engineering*, vol. 18, no. 6, March 15, 1918, pp. 284-285. Brief data on the growth of the American magnesium industry now concentrated in the hands of two companies, The American Magnesium Company, at Niagara Falls, and the Rumford Chemical Company, at Rumford, Maine. Some data are given on the production of magnesium-aluminum alloys.

SUBSTITUTES IN THE GERMAN ELECTRICAL INDUSTRY. Discusses the question of substitutes in the German electrical industry and the way it was handled. The greatest difficulty which the electrical industry had to face in Germany was the shortage of copper and its alloys. The Germans developed the use first of zinc in the form of drawn wire and succeeded in reducing to some extent its brittleness and sensitiveness to change of temperature. Further new alloys of magnesium appeared, such as electrone (10 per cent aluminum, 90 per cent magnesium). Older alloys such as magnalium and duralumin were also used as well as iron.

In insulating materials, paper in different forms and compositions have to take the place of former materials. Regenerated rubber, that is, refined rubber substitute, took the place of soft rubber, while for hard rubber is used an artificial product of phenol and formaldehyde called faturan (a product of the same origin is called bakelite in America).

As a substitute for oil in electrical apparatus, a material called benzinoform was proposed, a substance developed from carbon tetrachloride (the material used in America in fire extinguishers). So far the experience with it has not been satisfactory because of its excessive volatility. (*Engineering*, vol. 105, no. 2723, March 8, 1918, pp. 246-249.)

THE CONSTITUTION OF THE COPPER RICH ALUMINUM-COPPER ALLOYS, J. Neill Greenwood. *Engineering*, vol. 105, no. 2724, March 15, 1918, pp. 277-281, 6 figs., 16 tables (to be continued). First part of an investigation conducted in the metallurgical department of the Victoria University at Manchester. An abstract will be given in an early issue.

CONDENSER TUBE FAILURE—PHOTOMICROGRAPHY, F. W. Sterling. *Journal of the American Society of Naval Engineers*, vol. 30, no. 1, February 1918, pp. 99-103, 20 figs.

THE USE OF CORK IN AERONAUTICS, Arthur K. Barnes, *Aviation and Aeronautical Engineering*, vol. 4, no. 6, April 15, 1918, pp. 369-370, 4 figs.

THE STEEL BASE AND GALVANIZED SHEETS. *The Iron Age*, vol. 101, no. 15, April 11, 1918, pp. 934-935, 3 figs.

PRINCIPLE OF THE GENERATION AND APPLICATION OF HEAT IN STEEL TREATING, A. F. MacFarland. *American Machinist*, vol. 48, no. 15, April 11, 1918, pp. 627-630, 8 figs.

Evaporation

SOME PROBLEMS OF EVAPORATION, Harold Jeffreys. A mathematical treatment of the problem of evaporation, which the writer considers as being practically one of gaseous diffusion. With this in view he gives an equation identical in form with those that determine the transference of heat and momentum.

If V denote the fraction of the density of the air at any point that is due to water vapor, V will vary from time to time and place to place according to the equation

$$\frac{dV}{dt} = \frac{\partial}{\partial x}\left(k\frac{\partial V}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\frac{\partial V}{\partial y}\right) + \frac{\partial}{\partial z}\left(k\frac{\partial V}{\partial z}\right) \ldots\ldots [1]$$

where k is the effective coefficient of diffusion, t the time, and d/dt denotes the total differential following a particle of the fluid. In general, V, as above defined, will be referred to as the concentration.

Then if u, v, w be the components of velocity and V be supposed to be expressed as a function of x, y, z, and t,

$$\frac{dV}{dt} = \frac{\partial V}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial V}{\partial y} + w\frac{\partial V}{\partial z} \ldots\ldots [2]$$

The boundary conditions are that the air in contact with a liquid surface is saturated, so that V is equal to the concentration in saturated air at the temperature of the liquid, and that at the great distance.

When the transference is due entirely to turbulence, the quantity k has the same value in evaporation as it has in the case of transference of heat and momentum.

The rate of transference outwards is given by an equation which determines the rate of evaporation, the latter, other things being equal, being proportional to the linear dimensions, since the electrostatic capacity varies in this way on bodies of the same shape. In this way the present formula agrees with Stefan's solution, which has been experimentally proved to be correct subject to certain conditions.

The case of evaporation due to steady wind blowing over a flat surface of water is next considered, and an equation is given expressing the amount of evaporation taken over the whole area. In particular, it is shown that for areas of the same shape and dimension proportional to a, the rate of evaporation would be proportional to $a^{1\cdot5}$. This again is in accordance with the experimental results for bodies of medium dimensions discovered by Thomas and Ferguson.

The evaporation from a circular cylinder wet at the bottom and open at the top is considered next, as well as the very biologically important case of evaporation from the surface of a leaf. (*The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, vol. 35, no. 207, March 1918, pp. 270-280.)

TEST OF REILLY MULTICOIL EVAPORATOR (SUBMERGED TYPE), H. T. Dyer. A portion of the results of a test on this type of evaporator. It has been found that—

a There is an average reduction in capacity of about 11 per cent for each 1/32 increase of salinity.

b For each number of coils, vapor pressure and temperature difference there is a best water level for maximum capacity and safe operation with low chlorine content and no danger of priming.

c For vapor pressures below the atmosphere, the number of coils must be decreased to insure satisfactory operation.

d In order to obtain a capacity of 5000 lb. per hour for this evaporator, the blowdown must occur at intervals of 20 min. To avoid this too frequent blowdown, either continuous blowdown must be used or the water space of the evaporator must be greatly increased.

e The construction of the coils is such as to provide a very effective means of self-sealing of coils by sudden changes in temperature.

f The vapor produced is of exceptionally low chlorine content when the water level and temperature difference is within safe limits. (*Journal of the American Society of Naval Engineers*, vol. 30, no. 1, February 1918, pp. 78-98, 14 figs.)

TEST OF REGENERATIVE EVAPORATING APPARATUS, M. C. Stuart, Mem.Am.Soc.M.E. Data of tests recently made at the United States Naval Engineering Experiment Station, Annapolis, upon a patented system for the regenerative operation of evaporators, in which the efficiency of multiple effect evaporation was obtained with a single evaporator shell.

The essential feature of the system consists of a compressor called a "jetflo" compressor, Fig. 1, the function of which is to

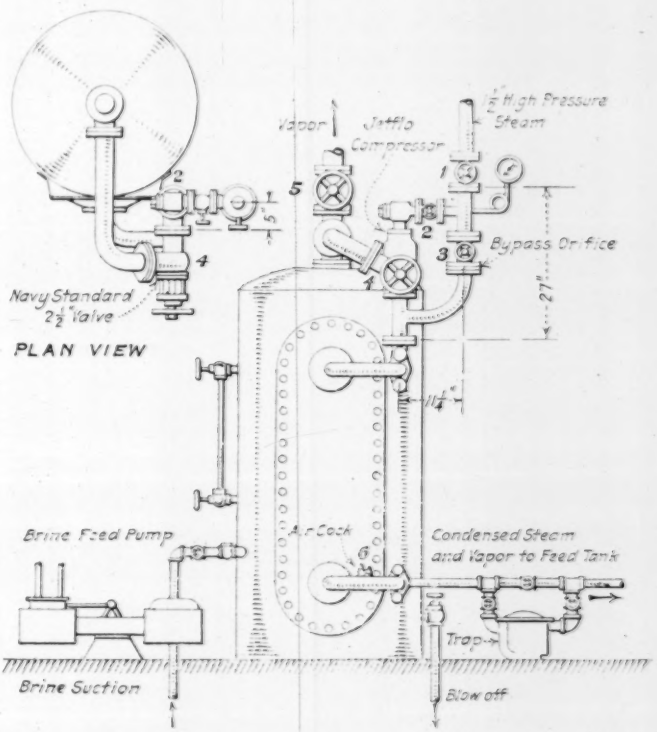


FIG. 1 JETFLO COMPRESSOR AND EVAPORATOR AS CONNECTED FOR THE TESTS DESCRIBED

compress, by the use of live steam, part of the vapor produced by the evaporator and to return to the coils of the evaporator the compressed vapor together with the steam used in compressing it.

The principal objects of the tests were to determine for various conditions of operation the amount of steam used by the compressor, the vapor entrained and compressed, non-entrained vapor produced, total vapor produced, amount of compression produced by the compressor and temperature difference maintained between coils and shell. Besides these data certain facts were established by the tests.

Comparative performances of the jet compressor when equipped with two separate nozzle tips, as well as the typical performance characteristics of the jet compressor, are shown in Fig. 2. In the lower curves the pounds of vapor entrained per pound of steam supplied are plotted against the amount

of compression produced. That there is a definite relation between these two quantities for constant steam and vapor pressures is shown by the fact that for each nozzle tip the test points for all runs fall on a smooth curve which may be

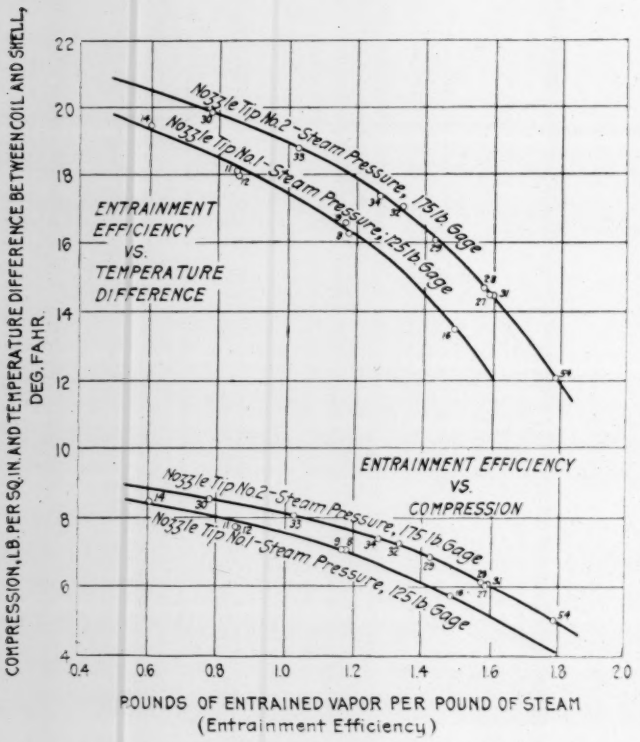

COMPRESSION, LB. PER SQ. IN. AND TEMPERATURE DIFFERENCE BETWEEN COIL AND SHELL, DEG. FAHR.
Nozzle Tip No. 2 - Steam Pressure, 175 lb. Gage
Nozzle Tip No. 1 - Steam Pressure, 125 lb. Gage
ENTRAINMENT EFFICIENCY VS. TEMPERATURE DIFFERENCE
ENTRAINMENT EFFICIENCY VS. COMPRESSION
POUNDS OF ENTRAINED VAPOR PER POUND OF STEAM (Entrainment Efficiency)

FIG. 2 COMPARATIVE PERFORMANCE OF TWO NOZZLE TIPS ON JETFLO COMPRESSOR

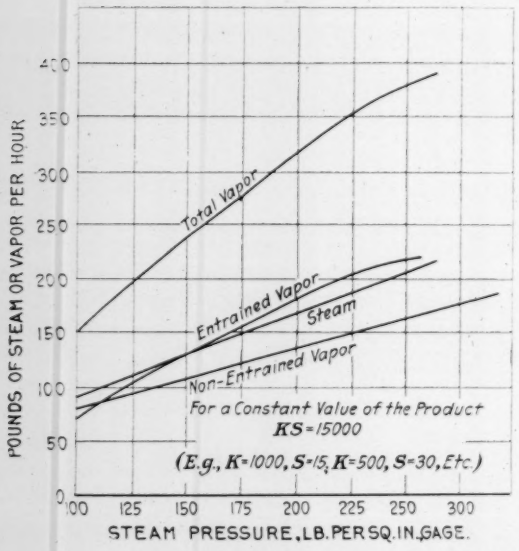

POUNDS OF STEAM OR VAPOR PER HOUR
Total Vapor
Entrained Vapor
Steam
Non-Entrained Vapor
For a Constant Value of the Product KS = 15000
(E.g., K=1000, S=15, K=500, S=30, Etc.)
STEAM PRESSURE, LB. PER SQ. IN. GAGE.

FIG. 3 CURVES SHOWING EFFECT OF STEAM PRESSURE ON CAPACITY OF COMPRESSOR

termed a characteristic of the compressor. In the upper curves the pounds of vapor entrained per pound of steam are plotted against the temperature differences, and here also the points for each nozzle tip fall on a smooth characteristic curve.

Lines of constant value of the ratio pounds of vapor entrained per pound of steam used, which might be termed the entrainment efficiency, were drawn by the use of the relation: weight of condensate = weight of steam times (1 + entrainment efficiency). Within the range of proper operation of the compressor the entrainment efficiency varied from zero to 1.89 lb. of vapor entrained per pound of steam used.

It developed during the test that the performance of the jet compressor in connection with the evaporators was constant for a constant value of the product of heat-transfer coefficient and surface; that is, if the compressor operated at a certain point in its characteristic with the value of $K = 1000$ and $S = 10$ sq. ft., it would operate at the same point for values of $K = 500$ and $S = 20$ sq. ft.

To show the effect of steam pressure on capacity and efficiency several curves plotted from test data are given in the original article. Thus, the curves in Fig. 3 show that for a value of the product $KS = 15{,}000$, the steam, non-entrained vapor and entrained vapor each increase with increasing steam pressure. From another figure not reproduced here and showing the variation of efficiencies with steam pressure, it is seen that the non-entrained vapor produced per pound of steam is nearly constant at various steam pressures; this is due to the fact that, approximately speaking, the latent heat of the entrained vapor forms a closed cycle within the apparatus, being alternately given to the entrained vapor in the shell, given up therefrom in the cells and reappearing as latent heat of the steam in the non-entrained vapor.

From still another figure it is apparent that both the efficiency and capacity are increased by increasing either the surface or the heat-transfer coefficient in the product KS. For the smaller amounts of surface there is a considerable variation in capacity and efficiency with heat-transfer coefficient, but with the larger amounts of surface installed there may be a considerable variation in the value of the heat-transfer coefficient with little effect upon the capacity and efficiency.

The heat balance of the system is shown diagrammatically in Fig. 4, which gives the distribution of all heat units involved in the production of one pound of vapor. A weight of 1.10 lb. of a mixture of steam and vapor is required in the coils to produce 1 lb. of vapor, in this respect the action being

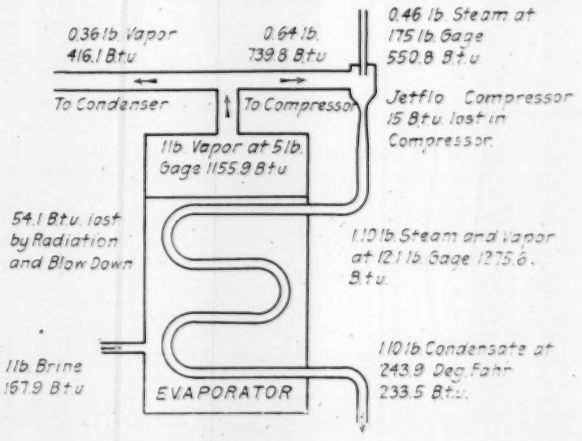

0.36 lb. Vapor 416.1 B.t.u.
0.64 lb. 739.8 B.t.u.
0.46 lb. Steam at 175 lb. Gage 550.8 B.t.u.
To Condenser
To Compressor
Jetflo Compressor 15 B.t.u. lost in Compressor
1 lb. Vapor at 5 lb. Gage 1155.9 B.t.u.
54.1 B.t.u. lost by Radiation and Blow Down
1.10 lb. Steam and Vapor at 12.1 lb. Gage 1275.6 B.t.u.
1 lb. Brine 167.9 B.t.u.
EVAPORATOR
1.10 lb. Condensate at 243.9 Deg. Fahr 233.5 B.t.u.

FIG. 4 HEAT BALANCE OF THE JETFLO COMPRESSOR SYSTEM

similar to the usual single-effect evaporator. The efficiency of the regenerative system lies in the fact that of the 1.10 lb. of mixture required in the coils only 0.46 lb. is required from the steam line and the remainder, 0.64 lb., is obtained from the entrained vapor which is compressed and returned to the coils and condensed in place of going to the distiller condenser to be condensed.

During operation of the evaporator the main steam valve

is opened wide, no throttling being required unless it is desired to operate at reduced capacity. When operating in connection with a distiller condenser in which atmospheric pressure is carried, the vapor valve to the condenser is opened wide. The valve in the vapor line to the compressor is left wide open, and the amount of vapor compressed and the pressure in the coils will adjust themselves. The maintenance of the proper water level, bleeding the air from the coils, attention to the drain from the coils and the maintenance of the proper salinity of the brine must be taken care of as in ordinary evaporator operation.

The system for the regenerative operation of evaporators, whereby part of the vapor is compressed by means of a jet compressor and returned to the coils, produces approximately the efficiency of a triple-effect plant in a single evaporator shell. The system operates with a relatively low temperature difference, and the amount of surface required to produce the desired capacity must be proportioned in accordance with the values tabulated in Fig. 2. An economical point of the design and operation of the system tested is for a steam pressure of 225 lb. gage and 17.48 sq. ft. of surface per 1000 gal. per day, assuming a heat-transfer coefficient of 1000. For these conditions the temperature difference will be 20 deg. fahr., and 2.15 lb. of total vapor is produced per pound of steam used. For lower values of heat-transfer coefficient the surface required must be increased inversely with the value of the heat-transfer coefficient. The use of a larger amount of surface results in increased efficiencies with the same amount of steam used. (*Journal of the American Society of Naval Engineers*, vol. 30, no. 1, February 1918, pp. 41-59, 12 figs., e)

Foundry

DIE-CASTING OF ALUMINUM-BRONZE, H. Rix and H. Whitaker. Paper read before the Institute of Metals on March 13, 1918, describing, among other things, the experiences of the authors in the production of die castings, especially 60:40 brass. A program for a scientific investigation into die casting is proposed, with a reservation, however, to the effect that the principal secret of die casting is experience. (*Engineering*, vol. 105, no. 2725, March 22, 1918, pp. 326-328, 1 fig.)

THE MANUFACTURE AND USE OF DIE-CASTINGS, Charles Pack. *Proceedings of The Engineers' Society of Western Pennsylvania*, vol. 33, no. 10, January 1918, pp. 668-692, 10 figs.

THE MANUFACTURE OF MANGANESE STEEL CASTINGS, B. S. Carr. *The Armour Engineer*, vol. 10, no. 3, March 1918, pp. 155-186, 25 figs. Description of the manufacture of die castings, mainly as carried out at the Chicago Heights plant.

URGE REVISED CASTING SPECIFICATIONS. *The Iron Trade Review*, vol. 62, no. 15, April 11, 1918, pp. 904-905.

Fuels and Firing

FURTHER NOTES ON FORCED DRAFT, C. H. Willey. *International Marine Engineering*, vol. 23, no. 4, April 1918, pp. 241-243, 2 figs. Description of the Howden system of forced draft, with practical instructions for its application.

COMBUSTION CHARACTERISTICS OF COAL, Joseph G. Worker. Discussion of the characteristics of coal mainly as affecting the selection of the equipment to burn the coal. From the paper it appears that the most important factor in the selection of stoker equipment is not the kind of coal to be burned, but the load condition of the plant. The available coal comes next, then draft conditions, and finally application conditions. A number of tests on the performance of various types of stokers with various coals are given. The coals discussed are anthracite, western bituminous, Pittsburgh, coke breeze, middle-western coals and lignite. (*The Electric Journal*, vol. 15, no. 4, April 1918, pp. 120-123, 5 figs.)

INCREASED EFFICIENCY THROUGH PROPER FURNACE CONSTRUCTION, Carl B. Harrop. *Brick and Clay Record*, vol. 52, no. 7, March 26, 1918, pp. 583-587, 8 figs.

OM UPPSKATTNING AV GASFORMIGA BRÄNNMATERIALS RELATIVA VÄRDE, Alf Grabe. Bihang till *Jern-Kontorets Annaler*, Arg. 19, no. 1, January 15, 1918, pp. 1-11, 2 figs., 2 tables. Description of methods of determining the relative heat value of gaseous fuels.

DIAGRAMME ENTROPIQUE DU PETROLE, M. Jean Rey. The physical laws of vaporization of gasoline are here expressed in the form of an entropy diagram, which will be reproduced in an early issue. The two main conclusions arrived at are that (1), the saturated vapor of ordinary gasoline is superheated through fall of pressure, and that (2), the heat of the liquid is always considerably higher than the heat of vaporization, both of these properties being opposite to those of water vapor. (*Comptes Rendus Hebdomadaires des Séances de L'Academie des Sciences*, Tome 166, no. 9, March 4, 1918, pp. 387-390, 1 fig.)

UNPREVENTABLE LOSSES IN COAL COMBUSTION UNDER BOILERS, Haylett O'Neill. Calculations showing the relative magnitude of the various unavoidable losses in the combustion of coal under boilers. Charts are given showing (1) the relation between hydrogen, excess of air and carbon dioxide, (2) ratio of moisture to dry air for various humidities, and (3) relation between ash in the coal and heat value. An interesting chart gives the separate and total necessary losses as calculated in the paper. (*Power*, vol. 47, no. 15, April 9, 1918, pp. 502-504, 5 figs.)

Hydraulics

LATERAL FLOW OF WATER UNDER LOW HEADS, Albert E. Guy. Discussion of flow through a lateral orifice, with special regard to the question of head causing such a flow.

The case under consideration is that of a container filled with water and provided with the lateral orifice near its lower end. If water be allowed to flow freely out of the orifice into the atmosphere, the velocity of flow through the most constricted section of the issuing jet is generated at any given instant by a head having for its height the distance from the center of the orifice to the level of the water in the container at that instant. This velocity is somewhat diminished by friction against the walls of the orifice, with the further reservation that the head measured should represent only an approximate average between those obtaining at the upper and lower strata of the jet. As the head is made smaller, the condition gradually approaches that of the flow in open conduits or in river beds.

The writer discusses the application in this case of Bossut's equation and its possible limitations, as well as its application to an orifice only partly filled vertically by the outflowing water. (Case investigated by Poncelet and Lesbros.)

In that case it was found (Fig. 5) that there was a very noticeable rise of the vein past the lower edge of the orifice, the angle at the edge being 54 deg. According to the theory

as explained by Bossut, the flow head should be the greatest above the edge. If so, the velocity would be maximum there and the underside of the vein would be expected to remain a horizontal plane for quite a distance from the sill. This rise of the lower part of the vein may be observed with any kind of orifice when the depth of water from the sill to the bottom of the container is larger than the vertical thickness of the vein through the orifice, and the writer believes that the true significance of such rise has not been realized previously.

This, in connection with the fact previously observed, that very definite stream lines exist throughout the mass of water in motion in the container and converge from all sides toward

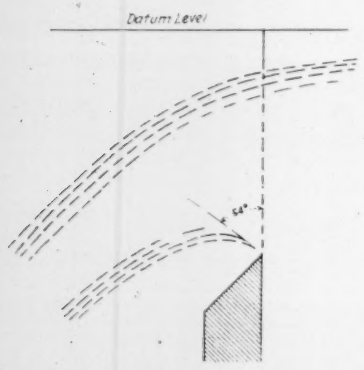


FIG. 5 PONCELET AND LESBROS EXPERIMENT ON THE FLOW THROUGH A PARTIALLY SUBMERGED ORIFICE

the orifice in the direction from the bottom to the sill, makes the so-called "varying flow-head theory" untenable.

From this the writer passes to the consideration of the general distribution of velocity at different points in the cross-section of a channel, and, referring to Fig. 6 (first shown by Darcy in 1857), he considers as predominant the fact that the velocity is very nearly constant along one even circuit, and in particular that it is practically the same at the lower extremity

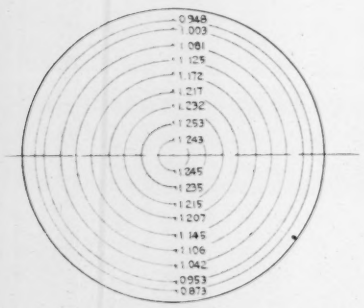


FIG. 6 DARCY CURVES OF VELOCITIES OF FLOW THROUGH A CEMENT PIPE

of a vertical diameter as at the upper end. It seems evident, therefore, first, since at the two ends of a vertical diameter the velocity is the same, that velocity is due to one head only, which in this case corresponds to the slope of the pipe, and second, that were it not for the frictional disturbances the velocity would be uniform throughout the whole section.

The question next discussed is whether there is a difference between a given cross-section of a stream flowing in a circular conduit and of a contracted vein flowing from a thin-plate orifice into the atmosphere, the flow being horizontal in both instances.

The writer shows that the usual assumption that the pressure within a jet is atmospheric is erroneous, and that the common practice in measuring the flow through a horizontal orifice by means of the pitot tube with the point of the tube placed along the horizontal diameter is wrong with such heavy fluids as water, since it results in showing a velocity, and, consequently, a volume, greater than the actual.

The measurement of hydrostatic pressures in the container and the question of various orifices are next discussed in detail. In this connection the writer discusses also the rotation of a jet issuing from an annular orifice, which he ascribes to the fact that the fluid is imperfect, that is, viscous, and is, therefore, subject to friction within itself, and also because the walls of the orifice and of the container are also imperfect and subject to friction. This friction is most intense along the edges of the orifice, and hence the streams in contact with the edge are retarded in their motion. Because of the velocity this retardation is communicated successively to the adjacent streams with diminishing intensity from the edge to the axis of the orifice where the velocity is known to be greatest, the axial portion of the jet flowing more easily and rapidly as the rest requires such active feeding from the upper level that a depression forms, which goes on increasing and assumes a funnel shape finally.

The most interesting part of the discussion is the theory that the velocity of flow of water issuing from a container through a lateral orifice into atmosphere is generated by the head or static height measured from the top of the contracted section of the issuing vein to the upstream level in the container. This assumes, of course, that the pressure upon the upstream level is that of the atmosphere; if it is not, the difference of pressure expressed in terms of head must be added or subtracted from the static height. (*Journal of the American Society of Naval Engineers*, vol. 30, no. 1, February 1918, pp. 60-77, 10 figs., *e*)

Internal-Combustion Engines

THE ENGINES OF THE GERMAN GOTHA BIPLANE. A series of articles is now appearing in *The Engineer* (the first article appeared on February 22, 1918) describing the engines of captured German aircraft. The first articles described the Maybach engine as used in the zeppelins and other airships. The present article describes the Mercedes engine as used in big Gothas.

One of the interesting features of this latter engine is the so-called half-compression gear used in order to reduce the compression when the engine is being started.

For this purpose means are provided (Fig. 7) whereby the camshaft may be moved longitudinally through a short distance so as to bring into action an additional face on each exhaust cam. The small auxiliary cam face is formed on the mid-axis of the exhaust cam towards one side and during the compression stroke opens the exhaust valve 12 deg. above the bottom dead center, and closes to 44 deg. before the top dead center. The edge of the auxiliary cam and of the roller in the rocker arm are beveled to 45 deg. to permit of easy engagement when the camshaft is shifted. The longitudinal movement of the camshaft is effected by partially rotating the handle shown at its end in the illustration. This handle is attached to a gun-metal collar contained within an aluminum housing and threaded internally.

The thread within the collar engages with the thread on the exterior of a steel sleeve, the forward end of which is flanged to engage with the double ball thrust bearing fixed to the end of the camshaft. The beveled gearwheel driving the camshaft

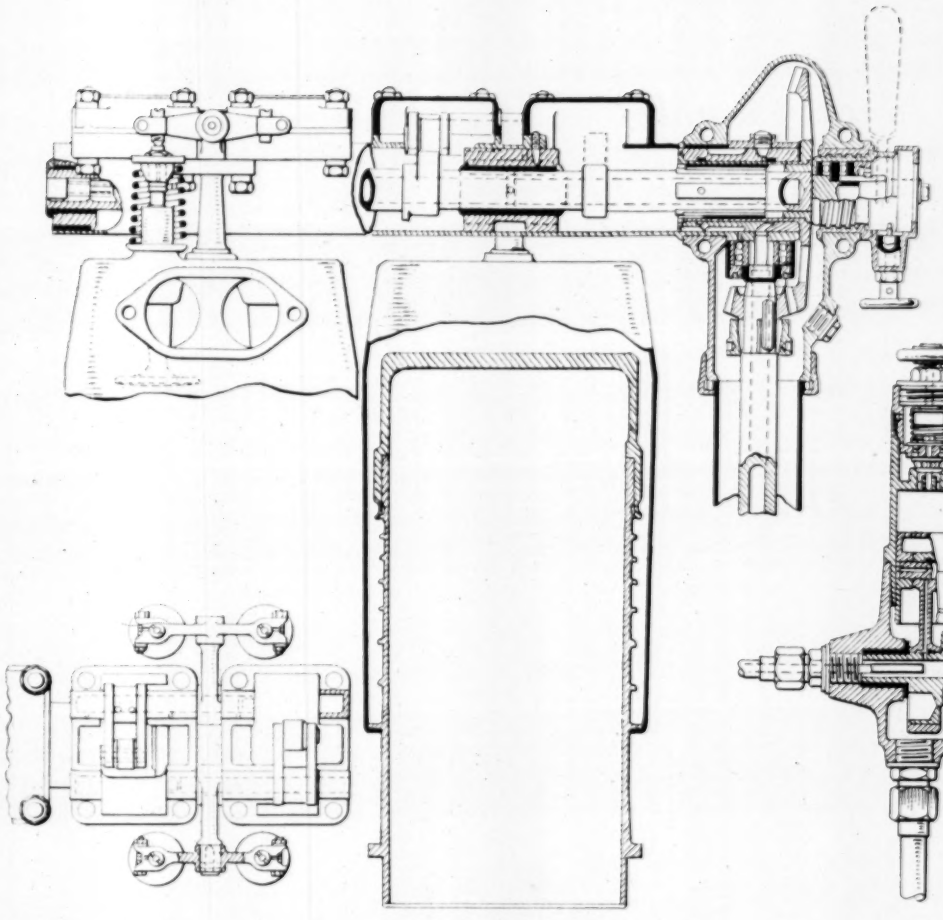


FIG. 7 ARRANGEMENT OF CAMSHAFT AND HALF COMPRESSION GEAR

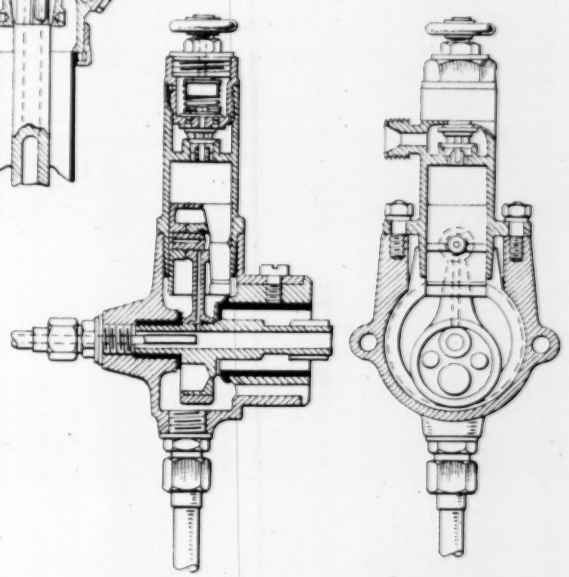


FIG. 8 AIR PUMP

has an extended boss that fits within a split gun-metal bearing driven into the rear end of the camshaft case. The interior of this boss has six serrations which engage with similar serrations on the camshaft so that the movement of the latter does not affect the meshing of the beveled wheel with the beveled pinion.

The drawing reproduced here is taken from an official report but it does not appear to be correctly sectioned.

The cooling water is circulated by means of a centrifugal pump disposed with the axis of its rotor vertical and collinear with the axis of the vertical shaft driving the camshaft—see Fig. 7. It is driven through bevel gearing from the crankshaft. As shown in the section of it given in Fig. 9, the pump draws its supply from below. The vanes formed on top of the rotor serve to throw the water away from the spindle, the object presumably being to assist in the prevention of leakake. The spindle is not provided with a packing gland. Instead of it a hardened steel washer is let into a groove turned in the upper face of the rotor and is pulled up against the lower end of the spindle bush by a spring acting, through a ball thrust bearing, against the under side of the flanged head of the spindle. The flanged head is provided with two claws that engage with the foot of a short vertical driving shaft as illustrated in Fig. 7. The spindle of the pump is lubricated by means of a grease cup operated by a ratchet from the pilot's seat.

The petrol is fed to the carburetor by placing the tanks under air pressure. The air pressure is supplied by a small pump, Fig. 8, mounted at the front end of the camshaft and driven by it through serrations, which preserve the driving connection when the half compression handle is rotated and the camshaft slides. The bore of the pump is 26 mm., camshaft diameter 27 mm. The drawing does not show the inlet port, but the delivery valve is seen on the center line above the piston. The air is delivered into a small chamber from which a connection is taken to the fuel reservoir. In the top wall of this

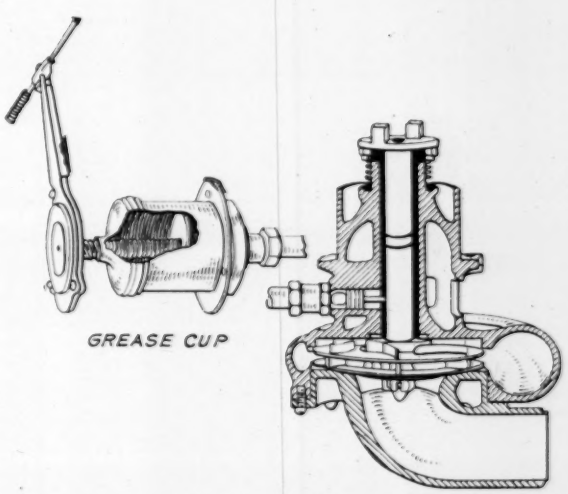


FIG. 9 WATER PUMP

chamber, ports (closed by a flat disk valve) are formed to relieve excess pressure. The strength of the spring behind the disk valve is adjustable by means of a screw handle, the stem of which is hollow and affords a passage for the surplus air.

The oil pressure pump, of a rather complicated design, is described in some detail in the original article. A special oil-supply pulsation damper is also described and illustrated. (*The Engineer*, vol. 125, no. 3244, March 1, 1918, pp. 182-184, illustrated, *d*)

Lubrication (See also Railroad Engineering)

STUDIO SUGLI OLI LUBRIFICANTI PER TRASFORMATORI. *Revista Tecnica delle Ferrovie Italiane,* Anno 7, vol. 13, no. 2, February 15, 1918, pp. 63-77, 2 figs., 1 chart.

STANDARIZED SPECIFICATIONS FOR LUBRICATING OILS, C. W. Stratford. Discussion of possible standard specifications for lubricating oil. As regards the stability of oils, the writer considers the oxidation test the only dependable and satisfactory one. The main facts shown by this test are the evaporation loss and the rate at which solid hydrocarbons are formed by polymerization or precipitation when oils are exposed to working conditions of an engine.

Distillation of finished oils under a high vacuum offers an unfailing means of determining their situation, that is, of what groups of hydrocarbons highly volatile or less volatile the finished oils may consist.

The various tests are described in detail, and the properties of representative American lubricating oils for use in internal combustion engines are given in a table.

It is stated that the investigation here discussed was carried out at the suggestion of the chairman of the Automotive Products Section of the War Industries Board. (*Aerial Age Weekly,* vol. 7, no. 1, March 18, 1918, pp. 48-51, 4 figs.)

Machine Parts

SAFETY AND RELIEF VALVES, M. W. Link. *International Marine Engineering,* vol. 23, no. 4, April 1918, pp. 172-174, 6 figs.

JOINTS AND JOINTING MATERIAL. *The Engineer,* vol. 125, no. 3245, March 8, 1918, pp. 212-213. The subject of jointing materials, both plastic and sheet packing, is discussed in detail, as well as such metallic joints as those of lead wool.

VALVE CAMS, Ernest G. Ritchie. Notes on the design of three types of valve cams—(1) a cam giving constant rate of change of acceleration, (2) a cam giving constant acceleration, and (3) a tangential cam.

The investigation here described indicates that a cam designed to give constant rate of change of acceleration has many advantages, and it should result in much "sweeter" motion of the valve gear, giving longer life of the moving parts. Also, it should result in higher volumetric efficiency so far as the engine itself is concerned. (*The Automobile Engineer,* vol. 8, no. 111, February 1918, pp. 34-36, 7 figs.)

FRICTION CLUTCHES, Herbert L. Towns. *The Automobile Engineer,* vol. 8, no. 3, February 1918, pp. 54-59, 12 figs. Paper presented to the Coventry Branch of the Graduate Section of the Institution of Automobile Engineers. The design of the various types of clutches is described in considerable detail.

Machine Shop

ANNEALING BY MUFFLE AND POT OVENS COMPARED, Jos. B. Deisher. Discussion of carbon losses in these two methods of treating malleable iron and data of tests made in this connection.

The writer points out that in the matter of annealing temperatures for malleable cast iron much depends on the chemical composition of the hard iron.

For many reasons it is often desirable to run the temperature considerably higher than 1400 deg., the maximum and minimum temperatures of annealing being in the case of pot ovens 1650 and 1450 deg. fahr., and in the case of muffle ovens 1700 and 1500 deg., respectively. Further, exhaustive tests have shown that prolonged annealing has no detrimental effect on the physical strength of the product unless the temperature is run too high, and it is safe to say that more poor malleable cast iron is produced by underannealing than by overannealing.

For reasons not generally announced it has been found necessary to hold castings at annealing temperature from 60 to 72 hours before the cooling process is commenced. Otherwise, the result will almost invariably show that the iron carbide has not been completely dissolved, this combined carbon causing brittleness.

The writer believes, however, that 60 hours are not actually required to dissolve the iron carbide and that its dissolution is largely a matter of heat penetration, particularly where the muffle-type oven is used, while in the pot oven there is little doubt but that the nature and composition of the packing material affects the dissolution of the iron carbide.

An opinion is expressed that had annealing temperature been made as high as the casting would stand at the beginning of the anneal, then the casting withdrawn before 60 hours of annealing had been completed and cooled very slowly, the result would doubtless have shown that a greater percentage of the carbon had precipitated as graphite. The writer recalls an incident where by accident the arch forming a muffle chamber in a muffle-type oven fell in and the fire had to be shut off about 36 hours before the regular time. The stack chamber and the oven were sealed up practically airtight and allowed to cool down as slowly as possible with the result that when the oven was opened the castings were found to be fairly well annealed. The carbide appeared to be completely broken up, but there was scarcely a trace of decarbonization visible without the aid of a microscope, which the writer ascribes to the fact that the annealing temperature was high when the accident occurred while the cooling was extremely slow, thus allowing plenty of time for the precipitation of graphite.

TABLE 1 COMPARATIVE RESULTS ON POT-OVEN AND MUFFLE-OVEN ANNEALING

	Pot Oven		Muffle Oven
	Mild packing	Strong packing	Without packing
Total carbon in hard iron, per cent	2.63	2.63	2.63
Combined carbon after anneal, per cent	0.53	0.13	0.05
Graphitic carbon after anneal, per cent	1.75	1.85	2.12
Total carbon after anneal, per cent	2.28	1.98	2.17
Total carbon removed in anneal, per cent	0.35	0.65	0.46
Wedge test, length of butt in inches	2⅞	2¾	2
Tensile strength, lb. per sq. in.	49,448	50,044	49,542
Elastic limit, lb. per sq. in.	38,746	37,122	37,398
Elongation, per cent in 2 in.	6.3	6.7	7.3

In the estimation of the writer, aside from the absolute necessity of first completely dissolving the iron carbide, the rate of cooling is of the utmost importance, particularly where it is desired to complete the annealing process in the shortest time possible. The writer recommends the following practice: To reach the highest temperature at the beginning of the anneal and hold it until the iron carbide is dissolved; then gradually dropped to 1400 deg., which, besides favoring the precipitation of graphitic carbon, would also lessen the danger of warping.

As regards the comparative advantages and disadvantages of muffle ovens, the principal advantages in favor of the muffle oven are: elimination of labor required to pack, handle and shake out the pots; cost of packing material; expense of renewing pots, etc. The disadvantages are: longer time required to bring the casting to annealing temperature; the castings are more apt to become warped or distorted. There is more danger of the castings becoming scaled due to the air leakage into the muffle and finally, small and delicately constructed castings cannot be annealed in this type of oven at all, unless they are packed in trays.

Table 1 gives the comparative results of pot-oven and muffle-oven annealing. (Paper presented at the Boston Convention of the American Foundrymen's Association, abstracted through *The Foundry*, vol. 46, no. 308, April 1918, pp. 154-158, *cp*)

THE SALVAGING OF HIGH-SPEED STEEL. *The Iron Trade Review*, vol. 62, no. 14, April 4, 1918, pp. 845-848, 16 figs. Popular description of some practical methods for conserving high-speed steel, including the discussion of electrically welded tools and the use of formed cutters.

TEMPLETS, JIGS AND FIXTURES, Joseph Horner. *Engineering*, vol. 105, no. 2724, March 15, 1918, pp. 274-277, 24 figs.

THE PROCESS OF CASE-HARDENING, E. Standiford. *American Machinist*, vol. 48, no. 13, March 28, 1918, pp. 542-544. Discussion of the process of case-hardening, giving a number of practical suggestions as to carrying out of the process. It is said that the best results have been obtained by allowing the pieces to cool after cementation and then reheating them before quenching. Interesting details are given as to the water hardening of the pieces.

MANUFACTURING THE ADDRESSOGRAPH, M. E. Hoag. *American Machinist*, vol. 48, no. 12, March 21, 1918, pp. 491-494, 13 figs.

DEVELOPMENT OF THE PNEUMATIC SAND-BLAST, Glenn B. Harris. *American Machinist*, vol. 48, no. 12, March 21, 1918, pp. 497-501, 4 figs. A descriptive article of a practical nature showing the different types of sand-blast and giving general suggestions as to the design and use of such apparatus.

Machine Tools

MANUFACTURE OF MACHINE TOOLS IN SWITZERLAND, C. E. Carpenter. It is said that the machine-tool industry of Switzerland has experienced a phenomenal growth since the beginning of the war. Tools of many types and sizes are being produced in large quantities, but the supply is not equal to the demand. In particular, exportation of machine tools has increased by leaps and bounds.

The types of machines which have figured most prominently in Swiss exports during the last years are engine lathes up to 24-in. swing and 12 to 15 ft. between centers, turret lathes up to 2-in. spindle capacity, bench precision lathe, thread milling machines for fuse work and shells, universal milling machines and grinding machines.

The various types of machines exported are briefly described. (*American Machinist*, vol. 48, no. 12, March 21, 1918, pp. 485-486.)

MAKING CONCRETE METAL-PLANING MACHINES, Ethan Viall. *American Machinist*, vol. 48, no. 15, April 11, 1918, pp. 603-608, 15 figs. Description of a strikingly novel type of metal planing machine. A more detailed abstract of this article will be presented in an early issue.

Measurements and Testing

AN ELECTROMAGNETIC CLUTCH INDICATING DEVICE, V. Karapetoff. *Automotive Engineering*, vol. 3, no. 3, March 1918, pp. 101-104, 3 figs. Description of an indicating device designed especially for use on the Entz magnetic transmission in motor cars, such as used on the Owen magnetic car.

ERICHSEN TESTS ON ALUMINUM SHEETS, Robert J. Anderson. Data of tests with the Erichsen ductility testing apparatus on annealed No. 18 gage aluminum sheets.

The Erichsen apparatus consists essentially of a die and holder for holding the sample to be tested and the internal tool actuated by a hand wheel which moves gradually forward until the sample is ruptured. The progress of the internal tool and the ultimate factor are observed in the mirror and the depth of indentation is read directly from a micrometer-graduated screw.

One of the distinctive features of this test is the evidence of approximate grain size of the metal tested which the fractured domes of the test pieces indicate. Particularly is this test of value as a guide to drawing operations on annealed metal. Under-annealed metal will rupture by deep draws, owing to its hardness and lack of ductility, while over-annealed metal will also rupture because of the weakened condition of the metal resulting from large grain size. The domes of the Erichsen test pieces indicate at once how a given metal may be expected to behave in the draw press, because, in fact, the apparatus is itself a miniature draw press. (*The Iron Age*, vol. 101, no. 15, April 11, 1918, pp. 950-951, 4 figs., 4 tables.)

TUBO PIEZOMETRICO DELL'IMPIANTO IDROELETTRICO SUL CORFINO, Luigi Mangiagalli. *L'Industria*, vol. 32, no. 2, January 31, 1918, pp. 44-52, 16 figs. Description of the arrangement of the piezometer tube at the hydroelectric installation of Corfino. An abstract of this article may be given in an early issue.

WATER GAUGES ON MARINE BOILERS, W. M. McRobert. *Mechanical World*, vol. 63, no. 1628, March 15, 1918, pp. 124-125.

MEASURING AIR AND GASES WITH THE PITOT TUBE, A. H. Anderson. *Compressed Air Magazine*, vol. 22, no. 3, March 1918, pp. 8692-8695, 3 figs., 3 tables.

Motor-Car Engineering

FUELS FOR TRACTOR ENGINES, Prof. J. L. Mowry. Brief data of an investigation carried out at the Department of Agricultural Engineering, University of Minnesota, with tractor engines showing the comparative efficiencies (or rather inefficiencies) of the various manifold used for burning kerosene. The author has found that in practically all cases there was a considerable dilution of the lubricating oil by kerosene after one hour's run. (*The Journal of the Society of Automotive Engineers*, vol. 2, no. 3, March 1918, pp. 222-225.)

THERMOSTATIC CONTROL CONSIDERATIONS, J. Edward Schipper. *Automotive Industries*, vol. 38, no. 13, March 28, 1918, pp. 637-639, 7 figs. Brief description of the two older systems of temperature control on motor cars, namely, straight thermostat and radiator shutters.

TRACTION ON BAD ROADS OR LAND, L. A. Legros. *The Journal of the Institution of Mechanical Engineers*, no. 3, March 1918, pp. 55-151, 163 figs., 2 tables.

Mechanics

SOME FUNDAMENTALS OF ROLLING SUPPORT, F. W. Gurney. A general discussion on the subject of bearings and their construction, including a comparison between ball bearings and roller bearings. The matter of increasing the area of contact between the ball and its raceway is discussed in some detail.

There is a limit to the closeness with which the race curvature may approach the curvature of the ball. In large bearings for carrying great loads at slow speeds the race contour is made very much closer than in high-speed bearings. In one case the chief consideration is load capacity; in the other, the consideration of load is practically negligible, but the reduction of friction is of supreme importance. Increasing the curvature of the race is one of two ways of increasing the available area of contact between the ball and its raceway. In ordinary practice the race curvature may be increased to an extent that will multiply the capacity of the ball many times before objectionable friction is incurred, but close race curvature spells safety for the bearing. In fact, the ball bearing made with close race contour is in effect a roller bearing. In it there are realized ample areas of contact which the advocates of the roller bearing particularly emphasize as an advantage. (*Journal of the Society of Automotive Engineers*, vol. 2, no. 3, March 1918, pp. 210-213, 4 figs., *g*)

WHIRLING AND WHIP OF A REVOLVING SHAFT, G. Greenhill. *Engineering*, vol. 105, no. 2724, March 15, 1918, pp. 273-274, 1 fig. (to be continued).

THE RESISTANCE OF A GROUP OF PILES, H. M. Westergaard. *Engineering and Cement World*, vol. 12, no. 7, April 1, 1918, pp. 22-26, 7 figs.

ON A NEW GYROSCOPIC PHENOMENON, E. E. Tournay Hinde. *Proceedings of the Royal Society*, Series A, vol. 94, no. A659, Mathematical and Physical Sciences, pp. 218-222, 1 fig.

DYNAMIC BALANCING, Commander F. J. Cleary. *Journal of the American Society of Naval Engineers*, vol. 30, no. 1, February 1918, pp. 1-22, 12 figs., 7 plates.

ON MOMENTS OF INERTIA, T. H. Jones. *Flight*, no. 478 (no. 8, vol. 10), February 21, 1918, pp. 201-202, 3 figs.

VOLUME OF TANKS WITH SPHERICAL ENDS, Harry Gwinner. *The Monthly Journal of The Engineers Club of Baltimore*, vol. 7, no. 5, November 1917, pp. 75-78, 2 figs.

Munitions

NEW PRESSURE TABLE FOR ELEY LEAD CRUSHERS, F. W. Jones. In the determination of shotgun pressure the Eley lead-crusher tables play a most important part. In fact, lead crushers are very convenient for testing of pressure in many kinds of rifles. They were not usually employed with military rifles because of the inconsistencies of results obtained with pistons of various sizes, which hitherto could not be properly explained. Some fifteen years ago an attempt was made to replace lead crushers by coppers of a special conical form, the object of this change having been to utilize the material for which exact calibration was possible. These crushers were given several years' trial in all the important testing stations in England, but ultimately they had to return to lead.

In 1913 a series of experiments on a very large scale was initiated for the purpose of building up a new table for Eley lead crushers. The process underlying these experiments was the taking of simultaneous records from pistons of alternative diameters. The pressure curve was worked out step by step in so many pairs of places that the resulting table must be accepted for all time as beyond dispute. It was not proved, and a fact that could not be proved at the time was whether the scale of tons pressure was correct or not. There were good reasons for believing that it was not correct, but as absolute values were not available the conventions of estimate were allowed to remain. Hence, the 1913 table gave all pressures in true proportion, but the real values could only be obtained by applying throughout a multiplier, which, at that time, was unknown.

Recently H. W. R. Mason revealed the data which explain the previous experience with lead crushers and provide figures for their exact calibration. He discovered that lead crushers developed a resistance during compression which varied with the amount of decrement, but was independent of the means by which the decrement was brought about. Whether the lead is squeezed in a press or reduced by the ordinary method of compression in a proof barrel, equal resistances are set up for equal decrements. The excess resistance developed by lead is transient and it disappears inside of 5 min. of decrement greater than 0.050 in. Thus, lead which is hardened by compression no matter to what degree, recovers to what may be termed the dead-soft condition inside a period of a very few minutes. In other words, it possesses the property of spontaneous annealing.

The rate at which this temporary hardness disappears grows with the degree of decrement and hence with the degree of resistance developed. For example, the dead-soft condition of a lead crusher compressed from 0.500 in. to 0.400 in. is reached in a period of 5 min. Whereas, the lead compressed to 0.340 in. recovers in the fraction of a minute. Tests of crushers which were made in ignorance of these facts were necessarily inconsistent, because nobody ever dreamed that time variations between successive treatments introduced so disturbing an influence. Now, however, when these conditions are understood, lead crushers may be tested by the simplest of all methods—that of the dropped weight.

The successive decrements produced by the repeated application of the same blow will not supply a true impact table of resistances, the reason being that the resistance developed by the initial blow has disappeared wholly or in part before the second can be delivered. Thus, three blows delivered in succession produce a greater total effect than the same three blows would do if they could be repeated so quickly that the lead had no time to anneal in the interval. In other words, three blows under practical conditions of experiment are not the equivalent of three times one blow. A true resistance table derived from impacts can be obtained by blows varying in amounts. For example, lead crushers may be submitted to blows of one, two, three, etc., pounds in successive series, and the difference in decrements between any two qualities of blow are those which would exist between successive blows by the same weight, supposing the disturbing effect of the time interval could be eliminated. The fact that it cannot is of no present concern, bearing in mind that alternative methods get around the difficulty. What is important is to realize that a succession of blows gives misleading results and should therefore be avoided.

Common sense supports the decision arrived at, for the ultimate object is to estimate powder pressure, and as powder produces its result in one continuous movement the method of calibration may be accepted which repeats this condition as nearly as may be. In point of fact, the time taken by a 3-lb. weight dropped from heights of 1 in. to 24 in. to compress the

crusher is about the thousandth part of a second. Again, the difference between the times of compression of 1-ft-lb. and 2-ft-lb. blows is less than the ten thousandth part of a second. The loss of hardness, or what is more aptly termed the error due to spontaneous annealing, may be ignored when dealing with such small time intervals—time intervals which are less than the period of duration of pressure in a shotgun proof barrel.

Mr. Mason made measurements of the decrements of Eley lead crushers from the drop of a 3-lb. weight released from nine different heights between the limits 1 in. and 24 in. The details having been published in these columns, it is now only necessary to assemble the results as in Table 2. For convenience, they may be stated with reference to a piston of 0.225 in. diameter. In that form they stand as pressure. Pressure can be converted into dead load by multiplying by 89.06, which is the product of one ton stated in pounds and the area of the piston. The word "resistance" has the same significance as "dead load," but it is more scientific because it better conveys an idea of the properties of a crusher in reference to the load it can support, for it can only support a given load provided it can bring to bear an equivalent value of resistance against the force seeking to compress it.

TABLE 2 RESULTS OF IMPACT EXPERIMENTS WITH ELEY LEAD CRUSHERS

Remaining length, inches	True pressure for 0.225-in. piston	Multiplier which gives agreement with Eley 1913 Table
0.4920	2.15	1.156
0.4779	2.77	1.130
0.4668	3.40	1.196
0.4572	3.66	1.172
0.4375	4.52	1.248
0.4104	5.60	1.302
0.3878	6.45	1.325
0.3678	7.12	1.332
0.3496	7.78	1.345

In the third column of this table there is no evidence of the equal multiplier which converts the Eley 1913 Pressure Table into absolute pressure values. As a matter of fact, there should not be, and this for reasons which must be carefully explained. According to the Eley table a remaining length of 0.3678 corresponds to a pressure 2.18 times greater than that corresponding to a remaining length of 0.478 in. The impact results by contrast show a ratio of 2.57 times for the same basic values. It has previously been stated that the Eley table conforms within itself, that is, one part with another, beyond all question of doubt. A much smaller testimonial has been accorded to the values arising out of Mr. Mason's experiments. No further sets of experiments are likely to be conducted which could compete in range and the exactitude with those upon which the Eley table is based. The appearance of disconformity of the impact results with the values of the Eley table must, therefore, be open to explanation, and the explanation is that the above impact results show the effect of resistance of statical loads, whereas in shotguns the pressure is applied in the manner known as dynamical.

The crusher may be loaded absolutely statically or absolutely dynamically, or any intermediate condition may exist between the two. In copper crushers an effort is made to eliminate dynamic tendencies and generally, if a crusher could be so designed that it would respond instantaneously to the applied pressure, its readings could be translated by a statical scale.

The writer discusses in detail the determination of pressure by means of a piston. In view of the irregular pressure given by shotgun cartridges an empirical rule had to be formulated for extracting real pressure results from the obviously excessive readings which followed when insufficiently compressed coppers were employed in connection with cartridges giving unexpectedly high results. The rule was to regard all pressure registered by decrements of 0.020 in. or under as true, while all decrements beyond this limit were treated as being in excess to the extent of half the surplus over 0.020 in. This rule proved of great assistance in tests with coppers and demonstrated that conical copper crushers under the conditions of use presented in shotguns are loaded partly dynamically, which may involve possible errors in the use of a table based on static behavior. The Eley table is, however, wholly dynamical and hence the figures of pressure do not represent the actual resistance of the crusher, though it is possible to obtain from a dynamical table a series of true dead-load or resistance values. By means of a rather complicated process, described in the

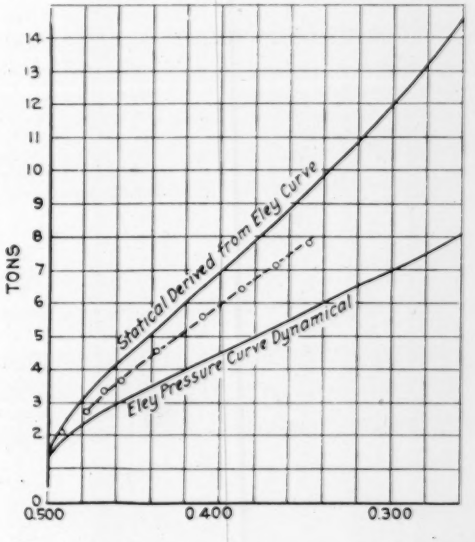


FIG. 10 ELEY LEAD CRUSHERS. PRESSURE ON A 0.225-IN. PISTON

original article, two curves were derived as shown in Fig. 10. The lower curve is that of the Eley table, from which the top one was derived. The resistances are shown for convenience as pressure on a 0.225-in. piston. Dynamical and statical curves for the same crusher are thus shown in contrast, and between them is another curve showing the resistances obtained from the drop-weight experiments. This curve shows that when a pressure was called 3 tons, it was, in reality only 85 per cent of 3 tons, or 2.55 tons. It must be decided in the future whether so much fiction can be allowed in a measurement which is otherwise fundamentally sound. The statical equipment of the Eley curve with the above correction becomes a dot curve in the figure, which agrees with the results of the drop-weight experiment to a very considerable extent. (*Arms and Explosives*, vol. 26, no. 305, Feb. 1, 1918, pp. 20-22, 2 figs., *ea*)

MANUFACTURE OF THE 4.7-INCH GUN, MODEL 1906-I, E. A. Suverkrop. *American Machinist*, vol. 48, no. 13, March 28, 1918, pp. 519-524, 10 figs.

RESISTANCE DES BOUCHES A FEU, L. Jacob. *La Technique Moderne*, tome 10, no. 1, January 1918, pp. 3-7. A mathe-

matical article discussing the stresses in the barrel of a gun and showing why composite barrel construction or hooped construction has to be used. An abstract of this article will appear in an early issue.

THE BROWNING MACHINE RIFLE AND GUN. *American Machinist*, vol. 48, no. 12, March 21, 1918, pp. 477-479, 2 figs.

THE 1917 CALIBRATION OF ELEY LEAD CRUSHERS, F. W. Jones. *Arms and Explosives*, vol. 26, no. 306, March 1, 1918, pp. 34-36, 1 fig., 2 tables. A continuation of the article on dynamical and statical pressures in Eley lead crushers, abstracted in the present issue. An abstract of this part will appear in an early issue of THE JOURNAL.

Power Plants

TAMARACK MILLS POWER PLANT, Charles H. Bromley. Describes the chief features of the new oil-burning plant furnishing light, heat and power to the Tamarack Mills, Pawtucket, R. I. The plant was designed solely for fuel, has a 2500-kw. extraction turbine, heats the mills with forced-circulation hot water and has the largest atmospheric cooling tower in New England. Unusually interesting performance figures are given. (*Power*, vol. 47, no. 13, March 26, 1918, pp. 426-430, 6 figs.)

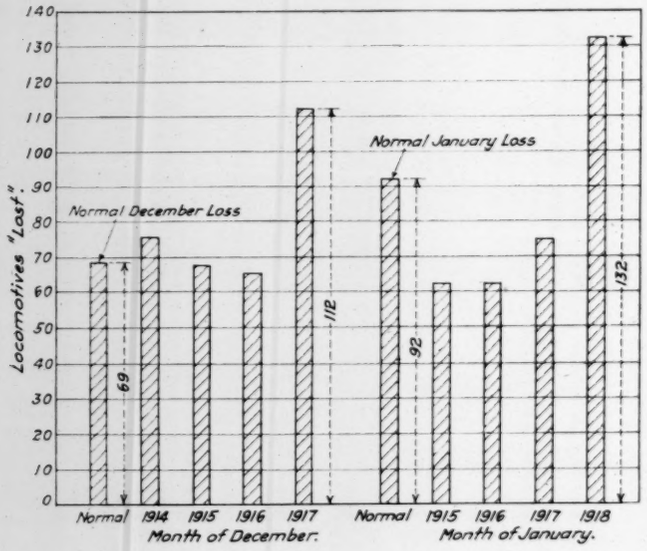


FIG. 11 ESTIMATED EFFECT OF WINTER TEMPERATURES ON TRAIN RESISTANCE STATED IN TERMS OF LOSS OF USE OF LOCOMOTIVES. (N. Y., N. H. & H. RR.)

Pumps

TESTS OF MAIN CIRCULATING PUMPS OF THE "NORTH DAKOTA" AND "NEVADA," Commander S. M. Robinson, U. S. N. Data of tests of the main circulating pump of the *Nevada*, carried out on board ship, and of the *North Dakota*, made by the Fore River Shipbuilding Company, and carried out partly ashore and partly on ship.

The paper presents a complete description of the method of carrying out the tests, and gives the data in the form of curves and tables.

Several points of design were brought out in these tests. Thus, when the *North Dakota* was placed in commission it was found that there was a sharp corner in the volute casting on the discharge side of the pump. This caused considerable vibration in the pump, which disappeared when the corner was removed. Another point in connection with the design of circulating pumps for use in connection with condensers on board ship referred to head and capacity conditions. The ordinary marine practice is to specify the head only approximately and to allow what is considered to be a liberal supply of circulating water. In the choice of the head an approximate figure is taken, no attempt being made to calculate the head from the actual condenser and piping, the result being that if the actual head varies considerably from this, the pump efficiency may be very low even with a good pump. This effect will be exaggerated if the water used is much less than the design calls for. The variation in the total head of condensers for the same horsepower is much greater than is commonly supposed. Thus, the total head at the same capacity is about three times as great for the *North Dakota* as it is for the *Nevada*. An attempt was made to analyze the various parts of the total head. (*Journal of the American Society of Naval Engineers*, vol. 30, no. 1, February 1918, pp. 23-40, illustrated, *e*)

Railroad Engineering

WINTER TEMPERATURES AND LOCOMOTIVE CAPACITY, W. L. Bean, Mem.Am.Soc.M.E. The unusually severe temperatures of the past winter have offered an opportunity to study the influence of decreased temperatures on the efficiency of steam locomotives. A drop in temperature decreases the capacity of the steam-locomotive boiler and also greatly increases the train resistance, the latter because journal friction increases as the temperature falls, owing to the increase in the viscosity of the lubricant. In fact, the first factor appears to be of much less importance than the latter.

Operating records in electric freight service between Harlem River terminals and New Haven, a distance of approximately 70 miles, with undulating curves of 0.6 per cent and considerable curvatures, afforded an opportunity to compare the consumption of power in winter with that of summer in a better manner than could have been done with steam locomotives.

The article explains in detail how "power-range" and "temperature-range" curves were found and compared. It was found that for each degree of temperature fall the demand for power increases 0.65 per cent.

This figure has been found from data secured with electric locomotives, but it is believed that the factor 0.65 per cent may be applied to steam-locomotive service as well, because there is no great difference in the heat losses and engine friction of steam and electric locomotives considered in percentage of maximum capacity, and heat losses in steam locomotives causing reduction in capacity in winter as compared with summer are practically offset for the purposes of this investigation by the consumption of current in heating cabs of electric locomotives, which latter required approximately 3 per cent of the total electric power used on a trip.

On the basis of the 0.65 per cent greater power required to move cars for each degree of temperature drop, excess-power requirements in last December and January as compared with those months in the three preceding years were as follows:

December, 1917

4.55 per cent greater than in December, 1914
5.55 per cent greater than in December, 1915
5.95 per cent greater than in December, 1916

January, 1918

8.71 per cent greater than in January, 1915
8.71 per cent greater than in January, 1916
7.15 per cent greater than in January, 1917

Assuming 800 locomotives normally in service, the result of such handicap, measured in the number of locomotives necessary to make up the increased demand for power on account of low temperature, was as follows:

December, 1917	January, 1918
36.4 engines more than in 1914	69.7 engines more than in 1915
44.4 engines more than in 1915	69.7 engines more than in 1916
47.6 engines more than in 1916	57.2 engines more than in 1917

Fig. 11 indicates the number of engines which would have to be added in a normal December and in a normal January to make up the loss of engines due to winter temperatures as compared with summer.

The writer calls attention to the fact that the foregoing estimates are based exclusively on the effect of low temperatures in causing increased resistance of trains through increased friction in bearings and increased heat losses in steam locomotives. There are numerous other ways in which low temperatures delay train operation and reduce the efficiency which have not been taken into consideration in the present instance. (*Railway Age*, vol. 64, no. 11, March 15, 1918, pp. 539-541, 3 figs., *epA*)

REPAIR AND MAINTENANCE OF LOCOMOTIVES IN WAR TIME, E. R. Battley. *Canadian Machinery and Manufacturing News*, vol. 19, no. 13, March 28, 1918, pp. 315-317.

U. S. A. GASOLINE LOCOMOTIVES. *Automotive Industries*, vol. 38, no. 14, April 4, 1918, pp. 686-687, 4 figs. Description of the gasoline locomotives manufactured for the United States Government by the Baldwin Locomotive Company. The general features of design do not materially differ from their standard type.

PROGRESS REPORT OF THE SPECIAL COMMITTEE ON STRESSES IN TRACK. *Bulletin of the American Railway Engineering Association*, vol. 19, no. 205, March 1918, pp. 875-1058, 141 figs., 13 tables. Report of an investigation carried out jointly by the American Railway Engineering Association and the American Society of Civil Engineers. A brief abstract of this investigation was published in the March issue of THE JOURNAL.

NEED MORE LABOR SAVING EQUIPMENT; Two Discussions of the Situation and Some Typical Examples of What Can Be Done. *Railway Maintenance Engineer*, vol. 14, no. 4, April 1918, pp. 131-132.

UNITED STATES RAILROAD ADMINISTRATION'S FREIGHT CAR EQUIPMENT STANDARDS. *Railway Review*, vol. 62, no. 13, March 30, 1918, pp. 459-467, 16 figs.

DIFFICULTIES OF LOCOMOTIVE LUBRICATION. *Railway Review*, vol. 62, no. 13, March 30, 1918, pp. 478-480.

SPECIFICATIONS FOR THE UNITED STATES STANDARD CARS. *Railway Age*, vol. 64, no. 13, March 29, 1918, pp. 785-788.

THE RAILWAY ENGINEERING CONVENTION. *Railway Review*, vol. 62, no. 12, March 23, 1918, pp. 417-425.

ONE HUNDRED TONS CAPACITY STEEL HOPPER CAR, NORFOLK & WESTERN RY. *Railway Review*, vol. 62, no. 14, April 6, 1918, pp. 495-497, 3 figs.

Research

THE RESEARCH COUPLET, RESEARCH IN PURE SCIENCE AND INDUSTRIAL RESEARCH, Wm. Allen Hamor. The writer discusses the interrelation between pure science and industrial research and expresses the view that the fundamental differences between pure research and industrial research are traceable to the differences in the poise and personality of the representatives of each type of scientific investigation.

With special regard to chemistry, it is pointed out that the great triumphs of pure chemistry are philosophic achievements, while all the conspicuous accomplishments in the domain of chemical industry are the outcome of the application of channels of knowledge explored by the investigators in pure chemistry.

An interesting classification of research in pure chemistry and in applied chemistry is offered.

Next comes research as developed by corporations. This appears to move through more or less well-developed stages according to the character of the industry. These stages may be presented as follows: First, research applied to the elimination of difficulties in manufacturing, and at least six American organizations have sixty or more research chemists engaged in this field of industrial research.

Next comes research having some new and specific commercial object. Frequently the appreciation of a need in industry for some new tool, method or material stimulates a deliberate search for means to satisfy that demand; or, again, it is sought to produce a commodity imported from another country or locality. This field of research proved especially profitable since the beginning of the war. Among the most progressive firms there is a growing appreciation of the fact that almost every discovery in science may ultimately have influence on industry. This leads to researches in pure science with no specific commercial application in view. This kind of research can be carried out only by large corporations, such as the General Electric Company, the Eastman Kodak Company, etc. It is a very far-seeing business policy directed to outstrip competition by the continuous provision of discoveries, which may sooner or later be turned to industrial account.

Research for the purpose of establishing standard methods of testing and standard specifications connected with the purchase of raw materials is a very important field of investigation, the necessity for which is obvious. (*The Scientific Monthly*, vol. 6, no. 4, April 1918, pp. 319-330, *g*)

AERODYNAMIC LABORATORY OF THE LELAND STANFORD JR. UNIVERSITY, Wm. F. Durand, Mem.Am.Soc.M.E. Description of this laboratory and its equipment, with special reference to tests on air propellers.

The purposes of the investigations for which the laboratory was designed were as follows:

First, the development of a series of design factors and coefficients drawn from model forms, distributed with some regularity over the field of air-propeller design and intended to furnish a basis of check with similar work done in other aerodynamic laboratories, and as a point of departure for the further study of special or individual types and forms.

Second, the establishment of a series of experimental values developed from models and intended for later use as a basis for comparison with similar results drawn from certain selected full-sized forms and tests in free flight.

The so-called Eiffel type of wind tunnel was adopted, described in some detail in the report.

An interesting feature of the design is constituted by the device for securing uniformity in flow into the test chamber from the mouth of the collector. With this in view a honeycomb structure was built in the delivery end of the collector. It is composed of hexagonal cells 3 in. in diameter and 10 in.

long made of roofing tin and soldered at the edges. This forms a stiff and true structure with thin walls presenting the minimum resistance to the flow of the air.

The form of the collector and diffuser tubes was determined by circular frames made by nailing up a double ring of ⅞-in. board segments, sawn to the proper curvature on one side, thus forming a strong ring of wood 1¾ in. thick. These rings were then fastened to uprights made of 2-in. by 4-in. scantling spaced about 2 ft. between centers and so adjusted vertically as to line up with the axis of the tunnel about 8 ft. 9 in. above the floor of the room. These circular rings, spaced out in this manner and each of appropriate diameter, give thus a series of transverse sections of the tunnel. The next step was to run longitudinal battens ⅞ in. thick by 2 in. wide along the inside of these rings, spacing them equally around the circumference. These battens were spaced about 6 in. between centers at the small end and 12 in. at the large end. This entire framework, when set up, cross-braced and stayed to the building, roof and floor, made a very stiff and secure skeleton on which to lay the inner covering forming the shell of the tunnel itself. This covering was of a good quality of heavy cotton sheeting laid on and stretched with care and secured along each longitudinal batten and running on the inside a small airplane batten approximately ¼ in. thick at the center by ¾ in. wide, thus holding the fabric down on the large battens.

The fabric was then treated with a standard airplane wing "dope" (celluloid dissolved in acetone), varnished and rubbed down to a smooth finish. At the propeller-fan end for a distance of about 4 ft. the number of longitudinal battens was doubled and for a distance of 1½ ft. the inside of the tunnel was covered with galvanized sheet iron in order to give necessary stiffness in the immediate vicinity of the tips of the blades of the fan. This general procedure gave a tunnel with a smooth, true and fair surface, conforming to the law of cross-sectional areas as determined, and, as later test showed, stable and without sensible vibration or disturbance under the highest wind velocities employed.

The experiment room was made of matched boarding laid on the inside of joists and studding spaced about 18 in. between centers. The highest wind speeds contemplated were not much about 60 m.p.h., and with a reasonable coefficient of flow through the collector tube this would require a reduction of pressure in the experiment room not much exceeding 10 or 12 lb. per sq. ft. This is a very moderate load, and no trouble was experienced in carrying it with ordinary framing covered with the matched boarding as indicated. To give light in the experiment room, two window sashes were fitted and the glass was reinforced on the inside with supports, reducing the size of the pane to the equivalent of about 9 in. by 10 in.

The room was made practically airtight by papering on the inside with heavy builders' paper laid on with a specially heavy paste. For entry and exit an airlock was provided with doors closing on suitable packing strips and fitted with self-adjusting hinges, allowing close contact between door and packing.

The air speed is measured by a pitot tube of the usual type. There is, however, also a sensitive pressure indicator showing the pressure head between the experiment chamber and the surrounding room, thus serving as an instantaneous air-speed indicator.

This pressure indicator consists of two manometric cells carried each on opposite ends of a sensitive balance. The lower ends of the cells dip under coal oil, the space above the liquid being connected in one case to the air in the experiment chamber and in the other, to the air in the surrounding room. The zero position of the scale is determined with both cups connected to the outer room. With one connected to the experiment room the balance becomes disturbed and the weights added to restore equilibrium furnish a direct measure of the depression within the experiment room. These indications calibrated against the pitot-tube measures of speed give the direct relation desired between the measure of the depression and the air speed at the propeller position. The weights for the balance were so selected as to give readings of pressure directly in pounds per square foot.

A relation was found based on pitot-tube determinations of velocity and manometric-balance measures of difference of pressure acting as an air head. This relation was found to be practically constant and equal to

$$\text{Velocity head} = 0.876\ (P_1 - P_2)$$

where P_1 and P_2 denote the pressure heads without and within the experiment room.

An interesting telephonic torque dynamometer is described in the same report. (*Journal of the Society of Automotive Engineers*, vol. 2, no. 3, pp. 230-238, 14 figs., *d*)

Refrigeration

ECONOMY OF THE REFRIGERATION POWER PLANT, Victor J. Azbe. *A. S. R. E. Journal*, vol. 4, no. 4, January, 1918, pp. 368-387, 11 figs. A discussion of the various sources of losses in a refrigeration power plant, with suggestions as to how such losses may be reduced or eliminated.

HEAT BALANCE OF THE AMMONIA COMPRESSION SYSTEM, J. H. H. Voss. For determining the economy of the ammonia-compression system three values are required: first, the external work or indicated horsepower expended in the compressor which may be determined from the indicator card; second, refrigerating effect; and third, the heat of condensation. Graphical methods are given for the determination of these three factors. (*A. S. R. E. Journal*, vol. 4, no. 4, January, 1918, pp. 345-367, 13 figs.)

A NATIONAL INDUSTRIAL RESEARCH LABORATORY. *The Engineer*, vol. 125, no. 3244, March 1, 1918, pp. 180-181. Description of the National Industrial Research Laboratory in England.

THE NATIONAL INDUSTRIAL RESEARCH LABORATORY, Sir Richard T. Glazebrook. *Engineering*, vol. 105, no. 2723, March 8, 1918, pp. 252-256, 5 figs.

THE HYDRAULIC LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Geo. E. Russell. *Journal of the Boston Society of Civil Engineers*, vol. 5, no. 3, March, 1918, pp. 121-130, 6 figs.

Steam Engineering

BOILERS WITH AIR HEATERS. Description of an installation where an air heater is provided for each boiler.

The installation described contains a 3000-kw. turbo-alternator driven by a turbine. There is one chimney for each four boilers and an air heater for each boiler.

The air is supplied to the air heater through a duct, Fig. 12, leading from the main generator in such a way as to utilize the heat of the air from the generators. It is heated to a comparatively high temperature in passing through the air heater, and from thence to the suction inlet of the fans, from which fans it is discharged to the Underfeed Stoker traveling grates.

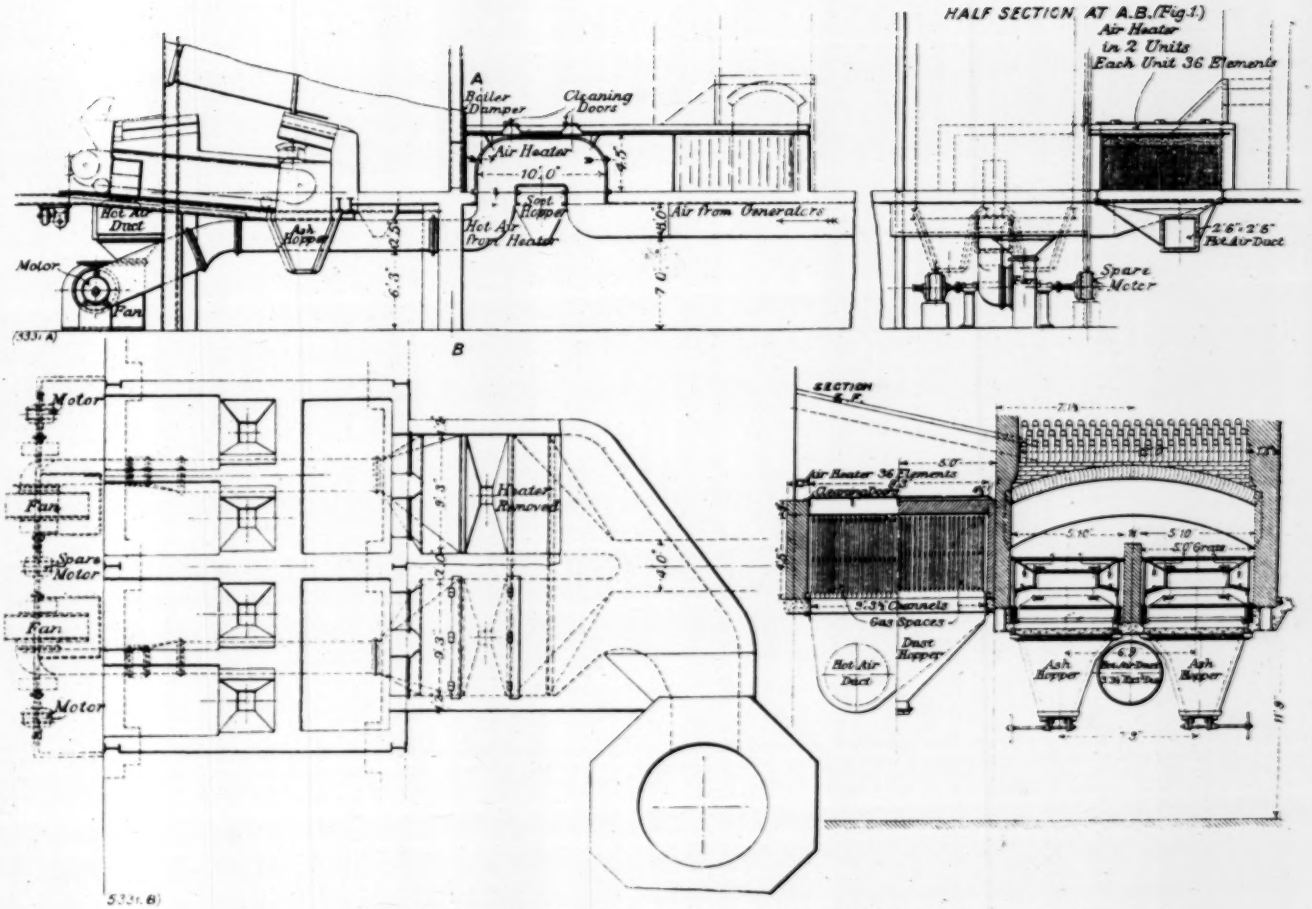


FIG. 12 USCO AIR HEATERS AND TRAVELING-GRATE STOKERS

The air heaters, as illustrated, each comprise 36 elements between which the hot gases of combustion flow from the boiler to the main flue. The warm-air main from the generators is splayed into 36 inverted U-branches. Each branch is further divided by a diaphragm to equalize the flow in the upper and lower portions. The total length of an element is 10 ft. and the depth 4 ft. 5 in., while the width of each heater chamber is 9 ft. 3 in. Below the heater there is a dust hopper, and above it there are cleaning doors.

The warm air is drawn into and through each heater by a fan driven by an electric motor. To guard against stoppages, a spare motor is provided in addition to individual motors for each fan. (The original article gives extracts from the specification, showing the extent and requirements of the plant). (*Engineering*, vol. 105, no. 2722, March 1, 1918, pp. 228-230, 5 figs., *d*)

BOILER BAFFLES OF PLASTIC MATERIAL. As a substitute for baffles for water-tube boilers consisting of tile, bricks or blocks of refractory material fitted in between the tubes, a composition is offered of refractory materials shipped in barrels in a plastic condition ready for use.

It is claimed that with this new material it is possible to secure jointless and gas-tight baffles, since the coefficient of expansion is so small that the change in shape due to variation of temperature may be neglected.

In forming a cross-baffle for a water-tube boiler of the Babcock & Wilcox Company type, the cast-iron baffle plate is employed as one side of the mold, while the other is formed by thrusting slats into the diagonals between the tubes, as illustrated in Fig. 13. The plastic material is then poked down through the diagonals to fill the space between the baffle plate and the slats, the material being sufficiently plastic to fit the tubes snugly. The boiler is then fired up slowly so that the slats will burn out while the plastic material is being dried and vitrified in place. (*Iron Age*, vol. 101, no. 12, March 21, 1918, p. 743, 1 fig., *d*)

FIG. 13 METHOD OF PUTTING IN BOILER BAFFLES OF PLASTIC MATERIAL

INCREASING THE LIFE OF ECONOMIZERS. With particular regard to New England, the average life of an economizer is from thirteen to eighteen years, depending on local conditions. After that the tubes become so thin that they are liable to fracture. This liability to fracture is greatly increased by any sudden shock, such as a water hammer, and, in fact, it is impracticable to carry the usual high boiler pressures.

The present article describes an arrangement for use with these older economizer installations whereby they may be protected from sudden shocks and excessive pressures.

The water is pumped from the primary heater through one stage of the chamber to the economizer at about 40 to 50 lb. pressure, and then from the outlet of the economizer to the suction of the second stage of the pump, where the pressure is increased to the required boiler pressure. See Fig. 14.

The application of this type of pump is said to have increased the life of several economizer installations. In one case where the repairs had become excessive a pump of this type was installed and the pressure cut down from 175 to 40 lb., which prolonged the life of the machine for a period of four years and eliminated practically entirely all the repairs

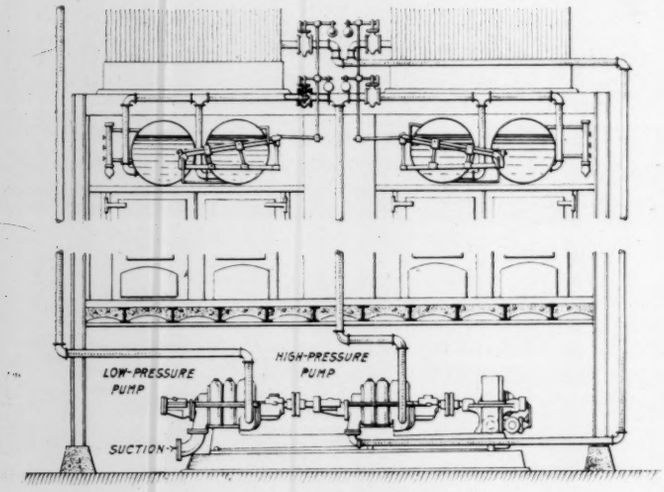


FIG. 14 CLARK AND SANTRY ARRANGEMENT FOR FEEDING WATER TO OLD ECONOMIZERS AT LESS THAN BOILER PRESSURE

due to tube and header fractures. (*Power*, vol. 47, no. 13, March 26, 1918, pp. 436-437, 1 fig., *d*)

WRECK OF A THIRTY-FIVE THOUSAND KILOWATT TURBINE. *Power*, vol. 47, no. 12, March 19, 1918, pp. 390-395, 7 figs.

CLEANING A CONDENSER WITH MURIATIC ACID, D. C. McKeehan. *Power*, vol. 47, no. 15, April 9, 1918, p. 504.

Varia

FERRO-CONCRETE SHIPS, T. J. Gueritte. *Engineering*, vol. 105, no. 2724, March 15, 1918, pp. 295-298, 3 figs., 4 tables.

WOMEN AS FOUNDRY WORKERS IN GERMANY. *Cassier's Engineering Monthly*, vol. 53, no. 3, March 1918, pp. 194-201, 4 figs.

ALCOHOL FROM SULPHITE-PULP WASTE LIQUOR, Ellwood Hendrick. *Metallurgical and Chemical Engineering*, vol. 18, no. 7, April 1, 1918, pp. 360-362, 3 figs.

NEW SERVICE TO CHECK TEREDO. *The Marine News*, vol. 4, no. 11, April 1918, p. 73, 2 figs.

THE FRENCH SYSTEM FOR RETURN TO CIVILIAN LIFE OF CRIPPLED AND DISCHARGED SOLDIERS, John L. Todd. *Publications of the Red Cross Institute for Crippled and Disabled Men*, Series 1, no. 5, February 28, 1918, 75 pp.

A BIBLIOGRAPHY OF THE WAR CRIPPLE, Douglas C. McMurtrie. *Publications of the Red Cross Institute for Crippled and Disabled Men*, Series 1, no. 1, January 4, 1918, 41 pp.

PROBLEMS OF HOT BLAST STOVE DESIGN, A. D. Williams. *The Blast Furnace and Steel Plant*, vol. 6, no. 4, April 1918, pp. 171-174, 1 fig., 10 tables.

BRITISH RECONSTRUCTION PLANS. *American Machinist*, vol. 48, no. 14, April 4, 1918, pp. 574-577.

METHODS OF GAS WARFARE, S. J. M. Wald. *The Journal of Industrial and Engineering Chemistry*, vol. 10, no. 4, April 1, 1918, pp. 297-301.

SOME APPLICATIONS OF ELECTROMAGNETIC THEORY OF MATTER, Albert C. Crehore. *Proceedings of the American Institute of Electrical Engineers*, vol. 37, no. 4, April 1918, pp. 283-315.

SHALL THE METRIC SYSTEM BE FORCED ON THE PEOPLE? Samuel S. Dale. *Scale Journal*, vol. 4, no. 6, March 10, 1918, pp. 5-7.

ARE YOU IN FAVOR OF PROGRESS, COMPETENCY AND EFFICIENCY? *Scale Journal*, vol. 4, no. 6, March 10, 1918, p. 11.

PROBLEMS IN ATOMIC STRUCTURE. *Engineering*, vol. 105, no. 2724, March 15, 1918, pp. 286-288, 5 figs.

POWER REQUIRED BY COLD ROLLING MILLS, C. E. Davies. *The Engineer*, vol. 125, no. 3246, March 15, 1918, pp. 221-222, 4 figs., 3 tables.

Charts

ALIGNMENT CHART FOR HERBERT'S CUBIC LAW, A. Lewis Jenkins. *American Machinist*, vol. 48, no. 13, March 28, 1918, p. 541.

MOMENTS OF INERTIA, T. H. Jones. *Flight*, no. 478 (no. 8, vol. 10), February 21, 1918, p. 201.

CHART SHOWING GRAPHICAL METHOD OF COMPUTING AVERAGE VELOCITY OF FLOW OF AIR, A. H. Anderson. *Compressed Air Magazine*, vol. 22, no. 3, March 1918, p. 8695.

CHART ON RELATION BETWEEN HYDROGEN, EXCESS AIR AND CO_2, and

CHART ON RATIO OF MOISTURE TO DRY AIR FOR VARIOUS HUMIDITIES, Haylett O'Neill. *Power*, vol. 47, no. 15, April 9, 1918, p. 502.

ALIGNMENT CHART FOR DEMPSTER SMITH'S FORMULAS FOR CUTTING SPEED, A. Lewis Jenkins. *American Machinist*, vol. 48, no. 15, April 11, 1918, p. 615.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

LIBRARY NOTES AND BOOK REVIEWS

ARTICLES of interest from the Library of the four Founder Societies, selected list of accessions during the month, and reviews of books of special importance prepared by members of the A.S.M.E. and others particularly qualified.

BOOKS AND MORE BOOKS

OUR soldiers and sailors here at home in the training camps, on transports, in the Navy and overseas in the trenches are urgently in need of good books. From every camp librarian we receive reports of a steady and large demand for technical works of every class. The need for engineering data is especially acute.

Over 600,000 books are now in use, but hundreds of thousands more are needed. Standing unused on shelves in our homes are many good books that would be of inestimable value in the camps. Office shelves bear books, seldom if ever touched, whose presentation to the Army would be a real service. Obviously, technical books sent should be recent editions.

The fund of $1,700,000 raised by the American Library Association to build and equip thirty-four libraries in the camps, to provide trained library service and to buy books, will not be adequate unless substantially reinforced by gifts.

To present books, all that is necessary is to mark them "War Library Service" and deliver them at any public library. They will be forwarded to the war-library storage plant and distributed to the points where they are most needed.

BOOK NOTES

Aids in the Commercial Analysis of Oils, Fats, and Their Commercial Products. By George Fenwick Pickering. J. B. Lippincott Co., Philadelphia, 1917. Cloth, 6x9 in., 133 pp.

Intended as a guide in works laboratories. The tests for determining the purity of the substances and their suitability for various purposes are given, together with tables of constants for each. These values, the author states, are here published for the first time.

Automobile Welding with the Oxy-Acetylene Flame. By M. Keith Dunham. A Practical Treatise Covering the Repairing of Automobiles by Welding, with a Non-Technical Explanation of the Principles to be Guided by in the Successful Welding of the Various Metals. The Norman W. Henley Publishing Co., New York, 1917. Cloth, 4x6 in., 167 pp. $1.

A manual for workmen which explains in simple language the principles of welding, and describes in detail their application in automobile repairing.

A Bibliography of the War Cripple. Compiled by Douglas C. McMurtrie.
The Economic Consequences of Physical Disability. By John Culbert Faries. A Case Study of Civilian Cripples in New York City.
Memorandum on Provision for Disabled Soldiers in New Zealand. By Douglas C. McMurtrie. N. Y. Red Cross Institute. New York, 1918. Paper, 8x11 in.

These pamphlets form the first three numbers of the publications of the Red Cross Institute for Crippled and Disabled Men. The bibliography covers 39 pages and will be further extended by supplements as new material accumulates.

Broaches and Broaching. By Ethan Viall. McGraw-Hill Book Co., Inc., New York, 1918. Cloth, 6x9 in., 221 pp., 188 illus. $2.

A summary of the present development of broaching work and machinery, written primarily to enable those interested to judge whether it is applicable to their particular class of work or not, and to provide working directions in the former case. Contents: Broaching and Broaching Tools; Standard Types of Broaching Machines; Examples of Pull Broaching Work and Practice; Examples of Push Broaching Work and Practice; The Design of Pull Broaches; The Design of Push Broaches; Making Broaches.

Brown's Directory of American Gas Companies, 1917. Compiled and Corrected Annually by E. C. Brown. The Gas Age, New York, 1917. Cloth, 7x11 in., 897 pp. $5.

This edition summarizes the statistics of 1179 manufactured, 768 natural, 134 acetylene and 70 gasoline gas companies, 161 parent or operating companies and 47 public service commissions. An appendix includes the financial data of 277 companies, the officers, directors and committees of gas associations and an alphabetical list of gas association members, with their company and association affiliations.

The Calorific Power of Fuels. By Herman Poole. With a Collection of Auxiliary Tables and Tables Showing the Heat of Combustion of Fuels, Solid, Liquid and Gaseous. 3d ed., rewritten by Robert Thurston Kent. John Wiley & Sons, Inc., New York, 1918. Cloth, 6x9 in., 267 pp., 65 illus. $3.

The introduction of new fuels, the improvements in the methods of investigating the calorific power of fuels and the increase in the amount of available accurate data have made it necessary to rewrite the book. The latest researches have been incorporated, inaccurate data occurring in earlier editions have been eliminated and the results have generally been reported in the English system of units instead of in the metric system used in former editions.

Chemical Patents and Allied Patent Problems. By Edward Thomas. John Byrne & Co., Washington, 1917. Cloth, 6x9 in., 58 pp. $2.50.

This work is intended to provide a statement of the law of the chemical patents, together with a practically complete list of the cases on which it is based, and of the principal cases intimately related in reasoning to them. Written from the point of view of the patent attorney and the expert witness.

Dyes and Dyeing. By Charles E. Pellew. Robert M. McBride & Company, New York, 1918. Cloth, 5x8 in., 274 pp., 24 illus., 3 pl. $2.

This book describes the modern dyes in non-technical language, discusses the theory and practice of color dyeing, and describes the methods of dyeing various fabrics and materials. Various methods of coloring objects in patterns are also described. It is intended for use by craftsmen doing small scale work.

The Elements of Railroad Engineering. By William G. Raymond. 3d ed., revised. John Wiley & Sons, Inc., New York, 1917. Cloth, 6x9 in., 453 pp., 107 illus. $4.

This book attempts to describe the fixed portion of a railroad plant and to give the underlying principles of the design of its layout. The present edition has been largely revised and the introduction has been modified to conform to the progress that has been made in the study of valuation and regulation of utilities, the discussion of engine capacity and the chapters on signaling have been rewritten, and a chapter on the principles of valuation has been added.

Essentials of Volumetric Analysis. By Henry W. Schimpf. An Introduction to the Subject, Adapted to the Needs of Students of Pharmaceutical Chemistry, Embracing the Subjects of Alkalimetry, Acidimetry, Precipitation Analysis, Oxidimetry, Indirect Oxidation, Idometry, Assay Processes for Drugs, Estimation of Alkaloids, Phenol, Sugars, Theory, Application and Description of Indicators. 3d ed., rewritten and enlarged. John Wiley & Sons, Inc., New York, 1917. Cloth, 6x8 in., 366 pp., 61 illus. $1.60.

This edition is revised to accord with the new United States